Detectors
for Ionizing Radiation

Including Codes of Practice

PTW THE DOSIMETRY COMPANY

General Remarks

1. All air-filled ionization chambers described in this catalog are shipped with a PTW calibration certificate for one measuring quantity (please specify), valid for the stated reference radiation quality.
2. The cable length of the detectors is 1 m, if not stated otherwise.
3. All detectors in this catalog can be operated with a PTW extension cable up to 100 m in length.
4. In case a detector is not used together with a PTW electrometer, the user must ensure that the polarizing voltage is applied by a current-limiting device with a maximum current of 0.5 mA.
5. Most detectors in this catalog are available with 3 different connecting systems (BNT, TNC and M type).
6. All technical data published in this catalog are typical data for the various detector types. Certain data of individual detectors may vary slightly within the ranges of tolerance.

Trademarks®

The following product names are registered trademarks of PTW Freiburg and PTW North America:
Advanced Markus, BEAMSCAN, Bragg Peak, DIAMENTOR, FARMER, Markus, microDiamond, NOMEX, PinPoint, ROOS, TRUFIX, UNIDOS.

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Looking Back on a Long History

PTW is a global leader in high-precision dosimetry solutions for radiation therapy, diagnostic radiology and metrology. Founded in Freiburg in 1922, we are one of the pioneers in radiation measurement, helping advance patient safety in modern radiation medicine. PTW technologies and services enable radiation experts in over 160 countries worldwide to precisely monitor highly complex clinical radiation equipment.

Our Operations

PTW Freiburg designs, develops, manufactures and distributes high quality dosimetry and QA equipment mainly for use in the medical field, especially in radiation therapy and diagnostic radiology. The development and production of mechanical, electronic and software components are all done in house. Our products, especially the PTW ionization chambers, are well known throughout the world and are recognized for their workmanship and high level of quality. PTW Freiburg is the market leader in its major product lines. The PTW distribution is organized internationally. A number of daughter companies and exclusive PTW representations are established in many countries around the world. We cooperate closely with official public agencies worldwide, and we participate actively in national and international work groups for the standardization of devices and procedures for dose measurement and quality control in radiation medicine.

Our History

In 1922, twenty-seven years after Röntgen discovered the X-rays, Professor Hammer from the Physics Institute of Freiburg University founded PTW to produce and market his development of an X-ray dosemeter based on the electrostatic relais, a revolutionary new electromechanical component for measuring very small electrical charges. In 1927, Dr. Herbert Pychlau took over the company and developed it during four decades into an internationally recognized manufacturer of quality dosemeters for medical radiology. PTW has developed and manufactured many generations of up-to-date products over the years, based on the latest technology. The company has grown continuously. Today, PTW employs a staff of more than 450 all over the world.

The Evolvement of Radiation Detectors

1922	Compact chambers with fixed preamplifier Hammer Dosimeter
1927	Barrel type chambers as secondary transfer standards Küstner Dosimeter
1928	Shadow-free chambers Schattenfreie Kammer
1930	Pressurized radiation protection chambers Streustrahlkammer
1932	Continuous monitoring therapy chambers Tubusrealais
1933	Water protected chambers for water phantom use Wasserphantom
1933	Capacitor chambers for "wireless" measurement Ionognom
1936	Waterproof sealed chambers for brachytherapy Mikrokammer
1950	Flat chambers for diagnostic radiology and mammography Flachkammer
1959	Transparent chambers for dose area product measurement DIAMENTOR®
1971	Pressurized well type chambers for nuclear medicine CURIEMENTOR®
1977	Plane-parallel low energy chambers Soft X-ray Chambers
1980	Dedicated electron chamber Markus Chamber
1985	Single and multiple detectors for brachstherapy AM6 Chamber
1989	Pencil chamber for computed tomography CT Chamber
1993	Diamond detector for water phantom use Diamond Detectors
1995	Liquid filled ionization chamber linear array LA 48 Array
1995	Diode detectors for diagnostic radiology DIADOS Detectors
1996	Well type chambers for brachytherapy source measurement HDR Chambers
1997	Ultracompact ionization chamber PinPoint Chambers
1999	Dosimetry diodes for water phantom use Dosimetry Diodes
2002	4π flat chamber for seed measurement SOURCECHECK
2003	2D ionization chamber array 2D-ARRAY seven29
2005	Ultracompact chamber with 3D characteristics PinPoint 3D Chamber
2005	Dedicated proton chamber Bragg Peak Chamber
2008	High resolution chamber matrix STARCHECK
2009	Fullsize high resolution chamber matrix STARCHECK maxi
2012	Liquid filled 2D ionization chamber array OCTAVIUS Detector 1000 SRS
2013	First synthetic diamond detector (SCDD) microDiamond
2015	High resolution chamber array for proton and heavy ion beams OCTAVIUS Detector 1500 XDR
2019	New generation of dosimetry diodes microSilicon and microSilicon X
2020	High resolution chamber array for SRS applications OCTAVIUS Detector 1600 SRS

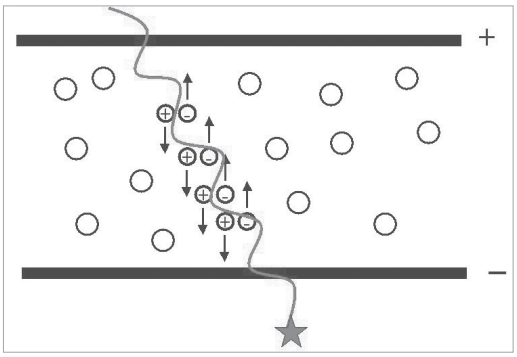
The Physics

General Aspects

Radiation detectors convert radiation energy into electrical energy. The electrical signal of a detector when irradiated is measured by an electrometer connected to the detector. By applying a certain detector specific calibration factor (e.g. Gy/C), the detector signal is related to a radiation dose value. Further correction factors depending on the detector characteristics and the beam quality may be used. A variety of detector types with different design for intensity measurements of ionizing radiation is available. The radiation detection for dosimetric purposes in the medical field of diagnostic radiology, radiotherapy and nuclear medicine is mainly based on three principles of measurement, realized by three different detector types: the ionization chamber, the silicon diode detector and the synthetic diamond diode detector.

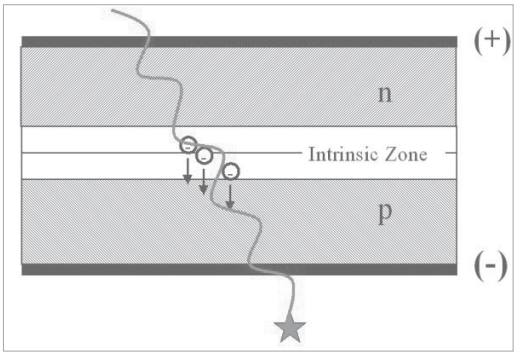
Ionization Chamber

An ionization chamber basically consists of a gas volume between two electrodes connected to a high voltage supply of typically 100 V to 1000 V. In this gas volume ionizing radiation creates ion pairs. These, being positive and negative charge carries, are attracted by the electrodes thus creating a current which can be measured by an electrometer. Gas (air) volumes vary from 0.005 cm^3 to 50,000 cm^3, corresponding currents can be between 10^{-14} A and 10^{-7} A. Using non-polar fluids, liquid-filled ionization chambers can be realized.



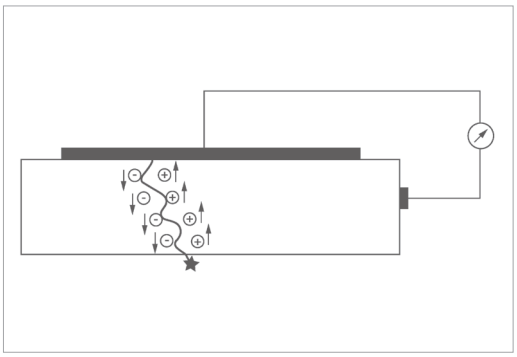
Silicon Diode Detector

In silicon semiconductors a layer of n-type silicon is brought into contact with a layer of p-type silicon, allowing electrons to drift from the n to the p region of the detector thus creating an insulating intrinsic zone. Incident radiation frees electrons in the intrinsic zone (sensitive layer of the detector) which move to the positively charged p region, generating a current. This solar cell principle does not need an external bias voltage.



Synthetic Diamond Diode Detector

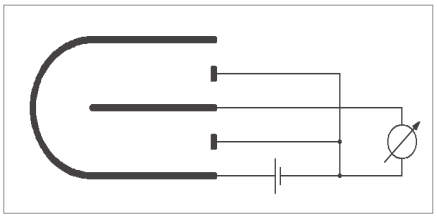
A Schottky diode develops below the top metal contact. The incident radiation generates positive and negative charge carriers. These are separated by the field of the diode, thereby producing a signal current that can be measured with an electrometer. Like the silicon semiconductors, no external bias voltage is required.



The Detector Design

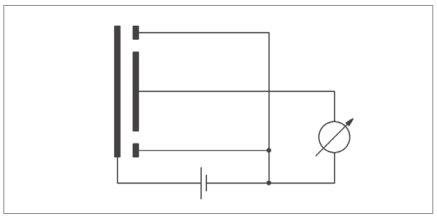
Thimble Ionization Chamber

A thimble chamber (also known as compact chamber) consists of a central electrode and a cylindrical chamber wall with a spherical or conical end, mounted on a cylindrical stem. A guard on central electrode potential leading up to the sensitive volume limits dark currents and stem effects.



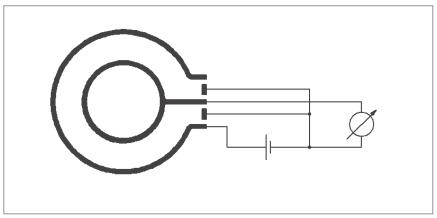
Plane-Parallel Ionization Chamber

A plane-parallel chamber (also known as flat chamber) consists of a high voltage electrode plate and a measuring electrode plate confining the sensitive volume. A guard on central electrode potential around the measuring electrode plate limits dark current and perturbation effect.



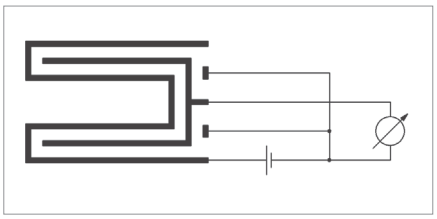
Spherical Ionization Chamber

A spherical chamber consists of two concentric balls representing the central measuring electrode and the chamber wall and confining the sensitive volume. A guard on central electrode potential around the measuring electrode stem limits the dark current.



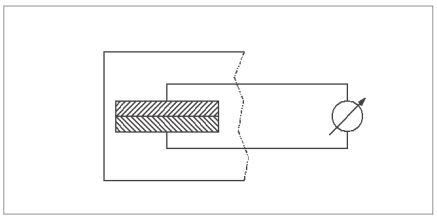
Well-Type Ionization Chamber

A well-type chamber consists of an outer housing with an insert cylindrical cavity - representing the chamber wall - to receive the measuring object. The measuring electrode also surrounds this cavity. A guard on central electrode potential around the measuring electrode stem limits the dark current.



Silicon or Diamond Diode

A silicon semiconductor or synthetic diamond detector consists of a layered silicon disk with contact wires to the measuring instrument. This is embedded horizontally or vertically in protective and / or build-up material depending on the intended application to form a useful probe. This detector does neither need an external bias voltage nor a guard.



PTW Calibration Laboratory

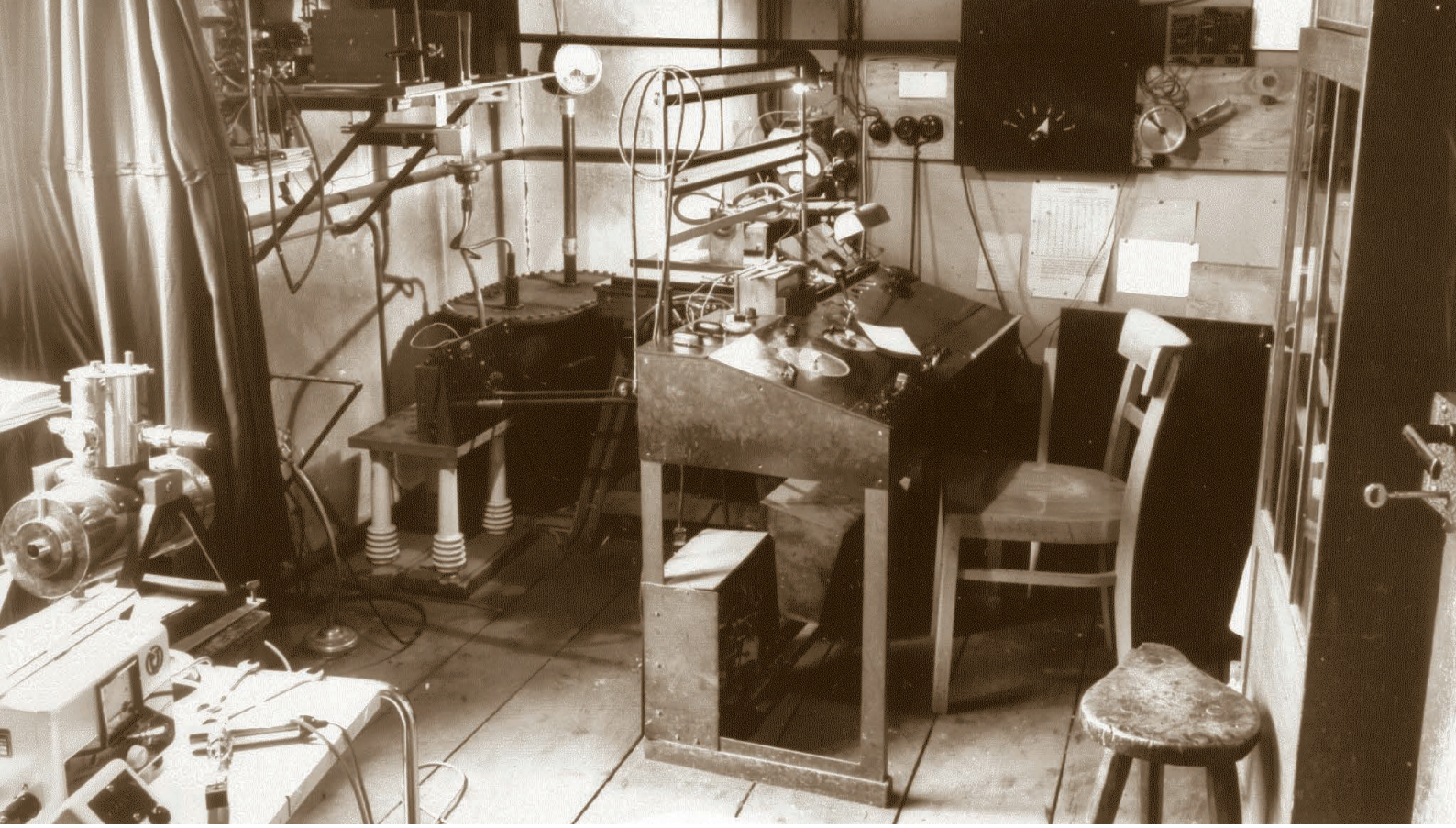
As both the oldest and the largest manufacturer of ionization chambers and medical dosimetry equipment, PTW Freiburg has always maintained a calibration laboratory for dosimetric measuring quantities. While being an integral part of the company and a key component of the PTW Freiburg comprehensive quality assurance system, the calibration laboratory is also proud of its very own traditions and achievements. The PTW Calibration Laboratory as an independent functional unit today is recognized internationally as one of the leading Secondary Standard Dosimetry Laboratories of the world.

Origin and tradition

PTW Freiburg was founded on May 9, 1922 for the purpose of manufacturing radiation therapy dosemeters based on the electrostatic relay invented by one of the founders, Prof. Hammer. Early photographs of the calibration laboratory show Hammer and Küstner dosimeters and their ionization chambers facing X-ray tubes supplied by open high-voltage leads. Calibration traceability to the National Laboratory (first (PTW, now PTB) always was of prime importance.
Original and improved versions of the Küstner Transfer Standard instrument in the PTW museum bear witness of that tradition. Internal traceability is proudly extended to the point of preserving the original measurement notes to every calibration performed since 1937. This traditional approach to quality today gives the laboratory the advantage of access to what is probably the largest database on calibrations of clinical dosimetry in the world.

Calibration facilities and instrumentation

Our facility is one of the largest, most modern commercial ionizing radiation calibration lab and repair facility in the world. In 2008 the space for the calibration lab is enlarged up to 900 sq. meters. Today the PTW calibration laboratory operates 12 separate calibration benches for radiological and radiotherapy measurements ranging from small mammography and soft X-ray facilities up to ^{137}Cs and the 220 TBq (6000 Ci) ^{60}Co radiotherapy standard. Work at all these single calibration places is coordinated using a custom-made laboratory software for process control, data acquisition from the calibration monitors (UNIDOS instruments) and calibration calculation for the department office writing the calibration certificates. As far as possible (for connector compatibility) the reference class UNIDOS electrometers are also used for the measurement of the customer chambers. The calibration in electrical measuring quantities of all electrometers used is also traceable to the PTB primary standard. Besides the dose and dose rate ranges the laboratory maintains facilities for the calibration of non-invasive kV-meters and nuclear medicine isotope calibrators.



Quality and regulatory compliance

Both as part of PTW Freiburg and as Secondary Standard Dosimetry Laboratory the PTW Calibration Laboratory is qualified by adherence to the most stringent QA standards. Current certifications comprise ISO 13485:2016, ISO 17025:2017 and Annex II and Annex V of the Directive 93/42/EEC (Medical Device Directive). Customers have the choice of Factory Calibration Certificate or Secondary Standard Calibration Certificate (DAkkS) for dose / dose rate calibrations.

Scope of work

Repair and electrical calibration of measuring instruments are mainly done for PTW dosimeters. This includes complete electrical recalibration of the modern electrometers through all their measuring ranges as well as early fault elimination by burn-in and comprehensive electrical safety tests. Whenever possible radiological calibrations include the adjustment of the instrument to directly display dose at the reference quality. Radiological calibrations are performed in the measuring quantities and radiation quality ranges as shown on page 8. For these calibrations every instrument from every manufacturer is accepted (as long as it works and physically fits within the beam). Special radiological calibrations are available upon request. In consequence the PTW laboratory is one of the busiest radiological calibration laboratories worldwide with over 12000 instruments calibrated every year.

Comparison measurements

Comparison measurements both in the form of direct comparisons in the calibration chain and ring comparisons between laboratories of equal rank are essential in documenting and maintaining traceability for any calibration laboratory. At the PTW Calibration Laboratory comparisons both with primary laboratories and with other secondary standard dosimetry laboratories are done on a regular basis. Traceability to PTB is maintained by calibration of six sets of dosimetry equipment every two years with comparative measurements and reports every three months. Comparison with IAEA is done by exchange of mailed TLD every year and occasional comparative measurements with ionization chambers. Deviations are always minimal. Participation in European Ring Comparisons (mostly also supplied with PTW equipment) continuously shows very successful results. TLD comparison measurements between IAEA and PTW both using IAEA system and the PTW TLD audit probes have shown only minimal differences.

Secondary Standard Laboratory Cooperation with IAEA and PTB

Having successfully participated in the regular comparisons for some years, since the year 2000 the PTW calibration laboratory is formally recognized as a Secondary Standard Dosimetry Laboratory in the IAEA/WHO SSDL network[1]. This so far is the latest expression of the extremely good and fruitful cooperation PTW has enjoyed with the IAEA Dosimetry Laboratory. (Since 1996 PTW has qualified and thrice requalified as preferred supplier of clinical dosimetry equipment to IAEA.) Another positive aspect of this cooperation is the mutual discussion of procedures and equipment which has lead to the design or continued development of several dosimetry components as for example the PTW Farmer chambers. A similar close cooperation is traditionally maintained with the German National Laboratory, PTB. Joint development has lead to such successful results as the Böhm extrapolation chamber and the Roos electron chamber. In the German DKD service of secondary standard laboratories PTW was the first and only laboratory for dosimetric quantities[2]. PTW is also one of the oldest members of this service (since 1980).

The PTW Lab in Figures

1922
The oldest private dosimetry calibration laboratory worldwide

17025
Accredited to international laboratory standard EN ISO/IEC 17025 since 1979

12000
Calibrations performed on average per year

2000
Member of the IAEA/WHO SSDL Network since 2000

12
Gamma and X-ray calibration facilities in full operation on 500 m^2

500
Different radiation detectors or instruments calibrated on average per year

[1]IAEA/WHO SSDL Newsletter No. 43 July 2000 page 42 (https://www-pub.iaea.org/MTCD/Publications/PDF/Newsletters/SSDL-NL-43.pdf)
[2]Physikalisch-Technische Bundesanstalt, DKD Deutscher Kalibrierdienst, Verzeichnis der Kalibrierlaboratorien, Ausgabe 3/ 2001 : DKD-K-01501 (https://www.dkd.ptb.de)

Interview with Dr. Christian Pychlau (Former Managing Partner PTW Freiburg)

Why is the calibration of dosimeters so important?
If radiation measuring equipment is not recalibrated regularly, the user runs the risk that it will not function as designed. Small but significant deviations within the measurements can thus remain undetected. The detectors and instruments are very stable and can generally be used for a long time, if handled professionally. We recommend recalibration for our own equipment once every two years. If a detector is defective to the extent that there are large deviations, this becomes immediately apparent to the user. However, small deviations of e.g. below five percent may go unnoticed in the daily hustle and bustle in the clinic. Regular calibrations allow errors to be discovered and corrected in time. Hence the call from us to all users: Take the calibrations seriously! If a detector behaves differently than it normally does, investigate it further in order to protect your patients.

Worst case scenario: What can happen if calibrations are not carried out regularly?
A detector can look intact from the outside but can still be defective. Detectors are generally very stable, but if an ionization chamber falls on the floor just once, or even if it is put down too hard on the table, it can be damaged.

In the 1990s a colleague of mine visited a number of rural hospitals in Asia. In many cases there were no doctors or physicists present, and staff had very little knowledge about medical physics. Thus, the dosimetry and quality assurance measurements were carried out – if at all – at a low level. He witnessed many deficiencies – from non-functional X-ray tubes to defective beam-scanning mechanisms, all of which could have been detected by appropriate quality assurance measures and calibrated equipment.

How can users assess the quality of a calibration?
A pre-requisite is the successful accreditation of the calibration laboratory to the current standards and then consistently positive audit results. One indication of high quality are the high level of qualifications and many years of experience of the laboratory staff. The PTW Secondary Standard Calibration Laboratory has been around since the 1920s. Every year we carry out more than 12,000 calibrations on hundreds of different dosimeters and appliances, including those of other manufacturers. Comparison measurements with PTB or IAEA are always within the pro-Mille range, therefore well below the combined uncertainty. These facts demonstrate the high quality of our calibrations.

Calibration Service - Radiation Qualities

Radiation Therapy Dosemeters

- X-rays 10, 15, 30, 50, 70, 100 kV
  (TW qualities according to DIN 6809-4)
- X-rays 70, 100, 140, 200, 280 kV
  (TH qualities according to DIN 6809-5)
- ^{137}Cs 662 keV
- ^{60}Co 1.3 MeV

Diagnostic Radiology Dosemeters

- X-rays 50, 70, 90, 120, 150 kV Conventional
  (RQR and RQA qualities according to IEC 61267)
- X-rays 70, 90, 120, 150 kV CT
  (RQR and RQA qualities according to IEC 61267)
- X-rays 100, 120, 150 kV CT
  (RQT qualities according to IEC 61267)
- X-rays 50, 70, 90 kV Dental
- X-rays 25, 28, 30, 35 kV Mammography
  Qualities according to IEC 61267
  Mo/Mo, Mo/Rh, Mo/Cu, Mo/Al, Rh/Ag, Rh/Cu,
  Rh/Rh, W/Ag, W/Al, W/Rh, W/Ti, W/Cu
  (each with 2 mm Al optional / total kV range: 20 - 49 kV)

Radiation Protection Dosemeters

- X-rays 10, 20, 30, 40 kV
  (Narrow Spectrum Series (N) qualities according to
  ISO 4037-1:1996)
- X-rays 60, 80, 100, 150, 200, 250, 300 kV
  (Narrow Spectrum Series (N) qualities according to
  ISO 4037-1:2019)
- ^{137}Cs 662 keV
- ^{60}Co 1.3 MeV

Miscellaneous Calibrations

- Source strength ($cGym^2h^{-1}$) of brachytherapy sources measured by well-type chambers
- Diagnostic X-ray generator high voltage of all types of X-ray equipment measured non invasively by kV-meters: Different ranges from 20 to 150 kV
- Nuclide activity in nuclear medicine measured by isotope calibrators (only CURIEMENTOR instruments)
- Electrical measuring quantities charge (C) and current (A) measured by highly sensitive electrometers

General Information

According to the PTW definition, each such set of beam qualities represent one calibration point for a certain application and can be ordered with a single order number. For more detailed information please refer to "Calibrations at PTW - A Short Guide" which you will find in the section Services-Calibrations on our website www.ptwdosimetry.com.

Detector Selector

Find the best detector for your application
The smart online tool at ptwdosimetry.com

8 Detectors found

Overall rating	Detector	Additional Selection Criteria: Fast measurement	Easy to use	Low price
★★★★	**T-REF (34091)** Reference detector for relative dosimetry in small fields. PTW recommends to use this reference detector for relative dosimetry in small and very small fields.	++++	+++	+++
★★★★	**microDiamond (60019)** Diamond Detector for dosimetry in high-energy photon, electron, proton and carbon ion beams, especially useful for small field dosimetry	+	+++	+
★★★★	**microSilicon (60023)** Waterproof silicon diode detector for dosimetry in high-energy electron and photon beams	+	++++	+++
★★★☆	**PinPoint 3D (31022)** Ultra small-sized therapy chamber with 3D characteristics for dosimetry in high-energy photon beams	+++	+++	+++
★★★☆	**PinPoint 3D MR (31025)** MR conditional small sized volume 3D chamber for dosimetry and End2End testing of the gating algorithm of MR LINACs	+++	+++	+++
	microSilicon X (60022)	+	++++	+++

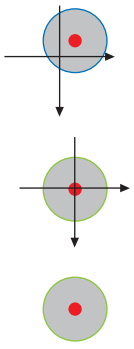
BEAMSCAN®

True all-in-one 3D water scanning system with wireless auto setup and operation

Measurements in small fields are always a challenge and at the same time a commitment for PTW to manage these measurements at its best.

The new BEAMSCAN software with dedicated features for small field dosimetry in combination with the high mechanical accuracy and the Auto Setup features makes BEAMSCAN the best choice also for small field dosimetry.

- Fast, fully automated, wireless setup with BEAMSCAN Wizard using
- Patented, fully automatic virtual tank leveling
- Wireless operation and data transfer
- Fast scanning (up to 20 mm/s)
- Supports Varian Halcyon™
- Continuous and step-by-step scanning mode
- Fully automatic water filling/draining
- Auto field alignment
- Advanced stainless steel worm drive with wave prevention
- Built-in, high-precision electrometer
- Reference-class Semiflex 3D ionization chambers as detectors, suitable for a wide range of field sizes
- TPR measurement included
- Integrated evaporation control
- Easy clip-in detector installation with new TRUFIX^{BS}
- Water tank with inclined bottom for complete draining
- Ample wheelbase – no extra weight on turntable



1
Measure X and Y profiles
→ Center the detector

2
Measure X and Y profiles again
→ Deduce FWHM field size and verify centering

3
Measure output factor

4
Set next field size

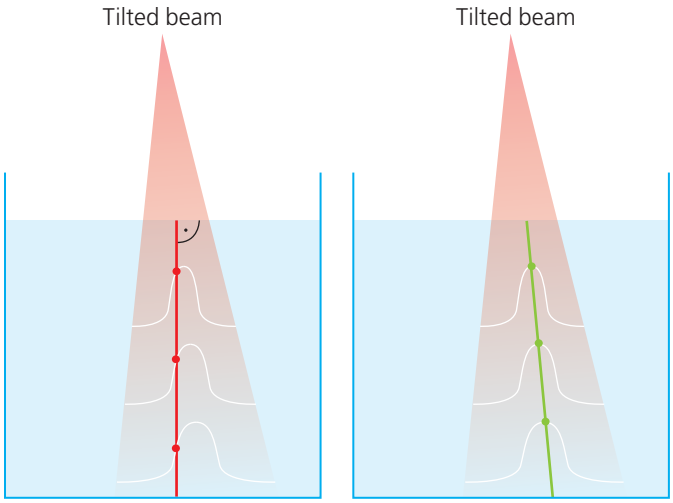
...and start again.

Taking all positioning and geometry information into account, this is the most accurate method to measure small field output factors.

Measures two profiles and calculates the shift in respect to the original zero position. Also the exact field size (FWHM) is measured.

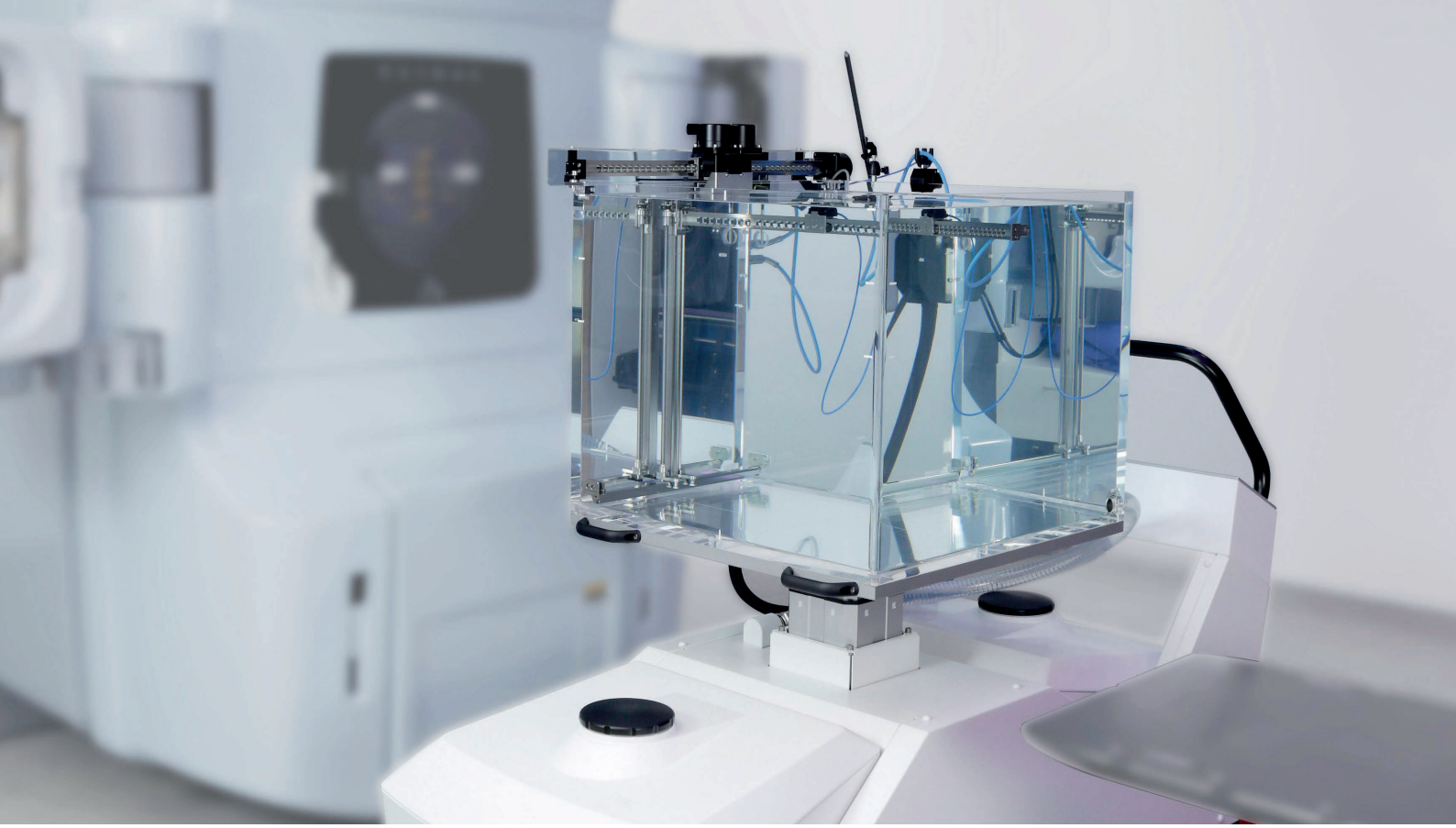
The measured beam inclination can be taken into account for other measurements.

Output factors are always measured in the beam maximum when the new function "Search maximum" is used before measurement of output factors.



BEAMSCAN measurement direction **before** correction
BEAMSCAN measurement direction **after** correction

Measure the beam inclination and set these angles for further measurements. The detector follows the inclination angles and measures always in beam center. Profiles are measured in different depth without CAX deviation.



Technical specifications

System	
Total dimensions	783 mm x 1548 mm x 1298/1798 mm (W x D x min./max. H)
Total weight	Approx. 240 kg (empty), approx. 440 kg (filled)

3D water tank	
Scanning range	500 x mm (horiz.) x 500 mm (horiz.) x 415 mm (vert.)
Wall thickness	15 mm

Built-in electrometer	
Channels	2
Resolution	10 fA
Chamber voltage	(0 ... ±400) V, programmable in 1 V increments
Dynamic range	2 pA … 500 nA in three ranges
Non-linearity	≤ ±0.5 % acc. IEC 60731
Long-term stability	≤ ±0.5 % p.a. acc. IEC 60731
Reproducibility	≤ ±0.5 % acc. IEC 60731

Driving mechanism	
Type	Stainless steel worm gear drive
Motor	Three stepper motors
Scanning mode	Continuous, step-by-step
Scanning speed	Up to 20 mm/s
Maximum speed	50 mm/s
Min. step size	0.1 mm

Lift carriage with built-in water reservoir	
Moving range	500 mm
Time for full lift	45 s
Min. step size	< 1 mm
Pumping time	Approx. 5 min (filling), approx. 7 min (draining)

UNIDOS® Tango

The Smart Reference Class Electrometer

Touchscreen **Ethernet/LAN** **WiFi**

Exceptional

As a secondary standard reference class electrometer that exceeds IEC and IPEM performance requirements, UNIDOS Tango delivers fast, reliable and highly accurate results across all applications. Equipped with industry-leading amplifier technology, it is exceptionally stable and ready for use immediately upon start. With the widest measurement range and best available resolution (0.1 fA) in the market, the new UNIDOS Tango is your tool of choice for high-precision measurements, e.g., in small field dosimetry.

Automated

Reduce setup time and improve measurement consistency with individual user profiles. Favorite device settings and detector parameters for frequent or specific measurement tasks, e.g., preferred measurement detector, user-defined correction factor and measurement range, can be saved as password-protected user profiles.

Intuitive

Its brilliant 5" capacitive touchscreen provides a clean, easy-to-navigate multi-lingual user interface, which gives you instant access to all relevant settings – in up to nine languages and with the simple touch of a finger. Measurement readings and other important data are always clearly visible on the screen and from any angle regardless of whether you are sitting or standing.

Connected

Touchscreen, hard-wired Ethernet or WiFi? Your choice. Use UNIDOS Tango as a standalone electrometer with intuitive touchscreen operation or control it remotely from your PC/laptop. Access its built-in webserver using any WiFi-enabled device, like your smartphone or tablet. As a smart electrometer with multiple connectivity options, UNIDOS Tango is incredibly easy and flexible in its operation.

Versatile

Readings are automatically saved to memory and immediately available for review. Access the last 50 measurements and quickly calculate mean value and standard deviation right on the spot. A comprehensive detector database with ready-to-use detector templates makes it easy for you to manage up to 100 different detectors and their calibration data conveniently from one place. Export measurement values to the Track-it data management software for documentation and constancy monitoring using optional BeamDose software.

DESIGN AWARD 2021

Less time. More safety.
Intelligent Detector Recognition (IDR)

UNIDOS Tango is the first electrometer worldwide that automates detector management and identification. By using detector-specific data matrix codes and intelligent 2D code scanning technology, it saves time and eliminates the chance for mistyped data, particularly in clinical environments with multiple electrometers and different detectors in use.

All in one code.

Each PTW detector suitable for reference dosimetry comes with a calibration certificate which also contains a unique data matrix code (DMC). It stores all detector-specific information, e.g., the calibration factor, calibration date and the name and serial number of the detector.

Scan code.

Updating the detector database of your UNIDOS Tango is very easy: Simply tap the DMC icon in the detector database, then point the data matrix code on your calibration certificate at the device camera. The built-in 2D code scanner reads the code and automatically enters all detector-specific information into the detector database of your UNIDOS Tango.

Identify detector.

Ready to perform a measurement? Hold the data matrix code that is printed on the label of your measurement detector in front of the device camera. The built-in 2D code scanner reads the code and calls up the correct detector simply by matching the data stored on the code to an entry in the detector database.

Notes

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Farmer® Chamber Type 30013

Waterproof therapy chamber for reference dosimetry in high-energy photon, electron and proton beams

- Acrylic wall, graphited
- Aluminum central electrode
- Waterproof
- Sensitive volume 0.6 cm^3, vented
- Reference class in accordance with IEC 60731 and AAPM TG-51 Addendum

The 30013 Farmer chamber is the standard ionization chamber for reference dose measurements in radiation therapy. Correction factors needed to determine absorbed dose to water or air kerma are published in the pertinent dosimetry protocols. Its waterproof design allows the chamber to be used in water or solid state phantoms. The acrylic chamber wall ensures the ruggedness of the chamber.

General

Type of product	vented cylindrical ionization chamber
Application	reference dosimetry in radiotherapy beams
Measuring quantities	absorbed dose to water, air kerma, exposure
Reference radiation quality	^{60}Co
Design	waterproof, vented, guarded
Direction of incidence	radial

Specification

Nominal sensitive volume	0.6 cm^3
Nominal response	20 nC/Gy
Long-term stability	≤ 0.5 % per year
Chamber voltage	400 V nominal ±500 V maximal
Polarity effect at ^{60}Co	< 0.5 %
Reference point	on chamber axis, 13 mm from chamber tip
Photon energy response	≤ ±2 % (70 kV ... 280 kV) ≤ ±4 % (200 kV ... ^{60}Co)
Directional response in water	≤ ±0.5 % for rotation around the chamber axis and for tilting of the axis up to ±5°
Leakage current	≤ ±4 fA
Cable leakage	≤ 1 pC/(Gy·cm)

Materials and measures

Wall of sensitive volume	0.335 mm PMMA, 1.19 g/cm^3 0.09 mm graphite, 1.85 g/cm^3
Total wall area density	56.5 mg/cm^2
Dimensions of sensitive volume	radius 3.05 mm length 23.0 mm
Central electrode	Al 99.98, diameter 1.15 mm
Build-up cap	PMMA, thickness 4.55 mm

Ion collection efficiency at nominal voltage

Ion collection time	140 µs
Max. dose rate for	
≥ 99.5 % saturation	5 Gy/s
≥ 99.0 % saturation	10 Gy/s
Max. dose per pulse for	
≥ 99.5 % saturation	0.46 mGy
≥ 99.0 % saturation	0.91 mGy

Ranges of use

Chamber voltage	±(100 ... 400) V
Radiation quality	30 kV ... 50 MV photons (10 ... 45) MeV electrons (50 ... 270) MeV protons
Field size	(5 x 5) cm^2 ... (40 x 40) cm^2
Temperature	(10 ... 40) °C (50 ... 104) °F
Humidity	(10 ... 80) %, max 20 g/m^3
Air pressure	(700 ... 1060) hPa

Ordering Information

TN30013 Farmer type chamber 0.6 cm^3, waterproof, connecting system BNT
TW30013 Farmer type chamber 0.6 cm^3, waterproof, connecting system TNC
TM30013 Farmer type chamber 0.6 cm^3, waterproof, connecting system M

Options

T48012	Radioactive check device ^{90}Sr
T48002.3.003	Chamber holding device for check device

Farmer® Chamber Type 30010

Classical therapy chamber for reference dosimetry in high-energy photon, electron and proton beams

- Acrylic wall, graphited
- Aluminum central electrode
- Sensitive volume 0.6 cm^3, vented
- Reference class in accordance with IEC 60731 and AAPM TG-51 Addendum

The 30010 Farmer chamber is a wide spread ionization chamber for reference dose measurements in radiation therapy. Correction factors needed to determine absorbed dose to water or air kerma are published in the pertinent dosimetry protocols. The acrylic chamber wall ensures the ruggedness of the chamber. The chamber is designed for the use in solid state phantoms and therefore not waterproof.

General

Type of product	vented cylindrical ionization chamber
Application	reference dosimetry in solid state phantoms and air
Measuring quantities	absorbed dose to water, air kerma, exposure
Reference radiation quality	^{60}Co
Design	not waterproof, vented, guarded
Direction of incidence	radial

Specification

Nominal sensitive volume	0.6 cm^3
Nominal response	20 nC/Gy
Long-term stability	≤ 0.5 % per year
Chamber voltage	400 V nominal ±500 V maximal
Polarity effect at ^{60}Co	< 0.5 %
Reference point	on chamber axis, 13 mm from chamber tip
Photon energy response	≤ ±2 % (70 kV ... 280 kV) ≤ ±4 % (200 kV ... ^{60}Co)
Directional response in solid state phantom	≤ ±0.5 % for rotation around the chamber axis and for tilting of the axis up to ±5°
Leakage current	≤ ±4 fA
Cable leakage	≤ 1 pC/(Gy·cm)

Materials and measures

Wall of sensitive volume	0.335 mm PMMA, 1.19 g/cm^3 0.09 mm graphite, 1.85 g/cm^3
Total wall area density	56.5 mg/cm^2
Dimensions of sensitive volume	radius 3.05 mm length 23.0 mm
Central electrode	Al 99.98, diameter 1.15 mm
Build-up cap	PMMA, thickness 4.55 mm

Ion collection efficiency at nominal voltage

Ion collection time	140 µs
Max. dose rate for	
≥ 99.5 % saturation	5 Gy/s
≥ 99.0 % saturation	10 Gy/s
Max. dose per pulse for	
≥ 99.5 % saturation	0.46 mGy
≥ 99.0 % saturation	0.91 mGy

Ranges of use

Chamber voltage	±(100 ... 400) V
Radiation quality	30 kV ... 50 MV photons (10 ... 45) MeV electrons (50 ... 270) MeV protons
Field size	(5 x 5) cm^2 ... (40 x 40) cm^2
Temperature	(10 ... 40) °C (50 ... 104) °F
Humidity	(10 ... 80) %, max 20 g/m^3
Air pressure	(700 ... 1060) hPa

Ordering Information

TN30010-1 Farmer type chamber 0.6 cm^3, PMMA/Al, connecting system BNT
TW30010-1 Farmer type chamber 0.6 cm^3, PMMA/Al, connecting system TNC
TM30010-1 Farmer type chamber 0.6 cm^3, PMMA/Al, connecting system M

Options

T48012	Radioactive check device ^{90}Sr
T48002.3.003	Chamber holding device for check device

Farmer® Chamber Type 30012

Farmer chamber with graphite wall for reference dosimetry in high-energy photon, electron and proton beams

- Graphite wall
- Aluminum central electrode
- Sensitive volume 0.6 cm^3, vented
- Reference class in accordance with IEC 60731

The 30012 Farmer chamber is intended for reference dose measurements in radiation therapy. Correction factors needed to determine absorbed dose to water or air kerma are published in the pertinent dosimetry protocols. The graphite wall makes the chamber almost water equivalent, the aluminum central electrode improves the energy response at energies below ^{60}Co. The chamber is intended for the use in solid state phantoms and therefore not waterproof.

General

Type of product	vented cylindrical ionization chamber
Application	reference dosimetry in solid state phantoms and air
Measuring quantities	absorbed dose to water, air kerma, exposure
Reference radiation quality	^{60}Co
Design	not waterproof, vented, guarded
Direction of incidence	radial

Specification

Nominal sensitive volume	0.6 cm^3
Nominal response	20 nC/Gy
Long-term stability	≤ 0.5 % per year
Chamber voltage	400 V nominal ±500 V maximal
Polarity effect at ^{60}Co	< 0.5 %
Reference point	on chamber axis, 13 mm from chamber tip
Photon energy response	≤ ±2 % (70 kV ... 280 kV) ≤ ±4 % (200 kV ... ^{60}Co)
Directional response in solid state phantom	≤ ±0.5 % for rotation around the chamber axis and for tilting of the axis up to ±5°
Leakage current	≤ ±4 fA
Cable leakage	≤ 1 pC/(Gy·cm)

Materials and measures

Wall of sensitive volume	0.425 mm graphite, 1.85 g/cm^3
Total wall area density	79 mg/cm^2
Dimensions of sensitive volume	radius 3.05 mm length 23.0 mm
Central electrode	Al 99.98, diameter 1.15 mm
Build-up cap	PMMA, thickness 4.55 mm

Ion collection efficiency at nominal voltage

Ion collection time	140 µs
Max. dose rate for	
≥ 99.5 % saturation	5 Gy/s
≥ 99.0 % saturation	10 Gy/s
Max. dose per pulse for	
≥ 99.5 % saturation	0.46 mGy
≥ 99.0 % saturation	0.91 mGy

Ranges of use

Chamber voltage	±(100 ... 400) V
Radiation quality	60 kV ... 50 MV photons (10 ... 45) MeV electrons (50 ... 270) MeV protons
Field size	(5 x 5) cm^2 ... (40 x 40) cm^2
Temperature	(10 ... 40) °C (50 ... 104) °F
Humidity	(10 ... 80) %, max 20 g/m^3
Air pressure	(700 ... 1060) hPa

Ordering Information

TN30012-1 Farmer type chamber 0.6 cm^3, C/Al, connecting system BNT
TW30012-1 Farmer type chamber 0.6 cm^3, C/Al, connecting system TNC
TM30012-1 Farmer type chamber 0.6 cm^3, C/Al, connecting system M

Options

T48012	Radioactive check device ^{90}Sr
T48002.3.003	Chamber holding device for check device

Semiflex 3D Chamber 0.07 cm³ Type 31021

State-of-the-art therapy chamber with excellent 3D characteristics for scanning systems and for reference dosimetry

- Waterproof, semiflexible design for easy mounting in scanning water phantoms
- Excellent 3D characteristics
- Sensitive volume of 0.07 cm³
- Reference class in accordance with IEC 60731 and AAPM TG-51 Addendum
- Designed for axial and radial irradiation
- Point dose patient QA with RUBY

The Semiflex 3D chamber is the advanced version of the Semiflex 0.125 cm³ (type 31010) chamber. It is the best choice for those who are looking for a small scanning detector and a detector for reference dosimetry. Both applications are perfectly covered to highest satisfaction. With its perfect balance between small-size volume, 3D design and a high response, the Semiflex 3D chamber allows you to perform dose measurements down to field sizes of 2.5 x 2.5 cm², but also meets the high-level requirements of the AAPM TG-51 Addendum and IAEA TRS-483 for a reference class chamber.

General

Type of product	vented cylindrical ionization chamber
Application	reference dosimetry in radiotherapy beams
Measuring quantities	absorbed dose to water, air kerma, exposure
Reference radiation quality	^{60}Co
Design	waterproof, vented, guarded
Direction of incidence	axial, radial

Specification

Nominal sensitive volume	0.07 cm³
Nominal response	2 nC/Gy
Long-term stability	≤ 0.3 % over year
Chamber voltage	400 V nominal, ±500 V maximal
Polarity effect ^{60}Co	photons ≤ ±0.8 % electrons ≤ ±1 %
Reference point	on chamber axis, 3.45 mm from detector tip
Directional response in water	≤ ±0.5 % for rotation around the chamber axis, ≤ ±1 % for tilting of the axis up to ±70°
Leakage current	≤ ±4 fA
Cable leakage	≤ 200 fC/(Gy·cm)

Materials and measures

Wall of sensitive volume	0.57 mm PMMA, 1.19 g/cm³ 0.09 mm graphite, 1.85 g/cm³
Total wall area density	84 mg/cm²
Dimensions of sensitive volume	radius 2.4 mm length 4.8 mm
Central electrode	Al 99.98, diameter 0.8 mm
Build-up cap	PMMA, thickness 3 mm

Ion collection efficiency at nominal voltage

Ion collection time	118 µs
Max. dose rate for	
≥ 99.5 % saturation	6.7 Gy/s
≥ 99.0 % saturation	13.4 Gy/s
Max. dose per pulse for	
≥ 99.5 % saturation	0.68 mGy
≥ 99.0 % saturation	1.42 mGy

Ranges of use

Chamber voltage	±(100 ... 400) V
Radiation quality	^{60}Co ... 50 MV photons (9 ... 45) MeV electrons
Field size	(2.5 x 2.5) cm² ... (40 x 40) cm² (3.0 x 3.0) cm² ... (40 x 40) cm² ≥ 18 MV
Temperature	(10 ... 40) °C (50 ... 104) °F
Humidity	(10 ... 80) %, max 20 g/m³
Air pressure	(700 ... 1060) hPa

Ordering Information

TN31021 Semiflex 3D chamber 0.07 cm³, connecting system BNT
TW31021 Semiflex 3D chamber 0.07 cm³, connecting system TNC
TM31021 Semiflex 3D chamber 0.07 cm³, connecting system M

Options

T48012 Radioactive check device ^{90}Sr
T48002.1.004 Chamber holding device for check device
T40072.1.130 RUBY detector holder T31021

Semiflex 3D MR Chamber 0.07 cm³ Type 31024

Ready for use MR conditional chamber with optimized MR imaging features and 3D characteristics

- Particularly suited for End2End testing of gating algorithm
- MR conditional (ASTM F2052-15 & ASTM F2213-17)
- Waterproof, semiflexible design for easy mounting in scanning water phantoms
- Excellent 3D characteristics
- Sensitive volume of 0.07 cm³
- Reference class in accordance with IEC 60731 and AAPM TG-51 Addendum
- Designed for axial and radial irradiation

The 31024 Semiflex 3D MR chamber is ideal for dose measurements in an MR environment encountered e.g. at MR-Linacs such as MRidian Viewray and ELEKTA Unity as well as for dose measurements in standard fields up to 40 x 40 cm². Relative dose distributions can be measured with high spatial resolution in any direction. The waterproof, guarded chamber can be used in air, solid state phantoms and in water.

General

Type of product	vented cylindrical ionization chamber
Application	reference dosimetry in radiotherapy beams
Measuring quantities	absorbed dose to water, air kerma, exposure
Reference radiation quality	^{60}Co
Design	waterproof, vented, guarded
Direction of incidence	axial, radial

Specification

Nominal sensitive volume	0.07 cm³
Nominal response	2 nC/Gy
Long-term stability	≤ 0.3 % over 2 years
Chamber voltage	400 V nominal ±500 V maximal
Polarity effect ^{60}Co	photons ≤ ±0.8 % electrons ≤ ±1 %
Reference point	on chamber axis, 3.45 mm from detector tip
Directional response in water	≤ ±0.5 % for rotation around the chamber axis, ≤ ±1 % for tilting of the axis up to ±70°
Leakage current	≤ ±4 fA
Cable leakage	≤ 200 fC/(Gy·cm)

Materials and measures

Wall of sensitive volume	0.57 mm PMMA, 1.19 g/cm³ 0.09 mm graphite, 1.85 g/cm³
Total wall area density	84 mg/cm²
Dimensions of sensitive volume	radius 2.4 mm length 4.8 mm
Central electrode	Al 99.98, diameter 0.8 mm
Build-up cap	PMMA, thickness 3 mm

Ion collection efficiency at nominal voltage

Ion collection time	118 µs
Max. dose rate for	
≥ 99.5 % saturation	6.7 Gy/s
≥ 99.0 % saturation	13.4 Gy/s
Max. dose per pulse for	
≥ 99.5 % saturation	0.68 mGy
≥ 99.0 % saturation	1.42 mGy

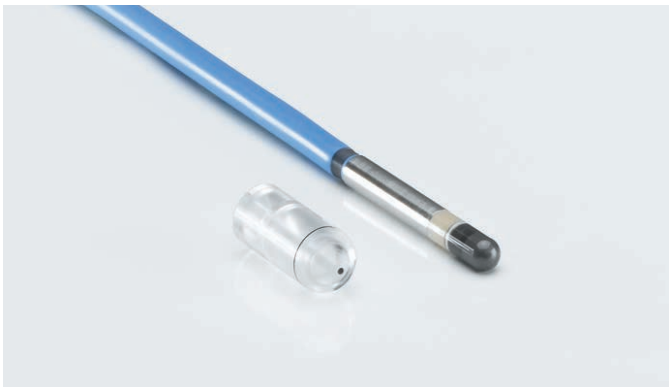
Ranges of use

Chamber voltage	±(100 ... 400) V
Radiation quality	^{60}Co ... 50 MV photons (9 ... 45) MeV electrons
Field size	(2.5 x 2.5) cm² ... (40 x 40) cm² (3.0 x 3.0) cm² ... (40 x 40) cm² ≥ 18 MV
Temperature	(10 ... 40) °C (50 ... 104) °F
Humidity	(10 ... 80) %, max 20 g/m³
Air pressure	(700 ... 1060) hPa

Ordering Information

TW31024 Semiflex 3D MR chamber 0.07 cm³, connecting system TNC

Semiflex Chamber 0.125 cm³ Type 31010



Standard therapy chamber for scanning systems and for reference dosimetry

- Waterproof, semiflexible design for easy mounting in scanning water phantoms
- Minimized directional response
- Sensitive volume of 0.125 cm³, vented
- Suitable for photon beams down to 140 kV
- Point dose patient QA with RUBY

The 31010 Semiflex chamber 0.125 cm³ offers a good balance between small size for reasonable spatial resolution and large sensitive volume for accurate dose measurements. The chamber volume of 0.125 cm³ provides enough signal for high-precision reference dose measurements. The sensitive volume is nearly spherical, resulting in a flat angular response and a uniform spatial resolution along all three axes of a water phantom.

General

Type of product	vented cylindrical ionization chamber
Application	reference dosimetry in radiotherapy beams
Measuring quantities	absorbed dose to water, air kerma, exposure
Reference radiation quality	^{60}Co
Design	waterproof, vented, guarded
Direction of incidence	radial

Specification

Nominal sensitive volume	0.125 cm³
Nominal response	3.3 nC/Gy
Long-term stability	≤ 1 % per year
Chamber voltage	400 V nominal ±500 V maximal
Polarity effect at ^{60}Co	< 2 %
Reference point	on chamber axis, 4.5 mm from detector tip
Photon energy response	≤ ±2 % (140 kV ... 280 kV) ≤ ±4 % (200 kV ... ^{60}Co) ≤ ±5 % (50 kV ... 150 kV)
Directional response in water	≤ ±0.5 % for rotation around the chamber axis and for tilting of the axis up to ±10°
Leakage current	≤ ±4 fA
Cable leakage	≤ 1 pC/(Gy·cm)

Materials and measures

Wall of sensitive volume	0.55 mm PMMA, 1.19 g/cm³ 0.15 mm graphite, 0.82 g/cm³
Total wall area density	78 mg/cm²
Dimensions of sensitive volume	radius 2.75 mm length 6.5 mm
Central electrode	Al 99.98, diameter 1.1 mm
Build-up cap	PMMA, thickness 3 mm

Ion collection efficiency at nominal voltage

Ion collection time	121 µs
Max. dose rate for	
≥ 99.5 % saturation	6 Gy/s
≥ 99.0 % saturation	112Gy/s
Max. dose per pulse for	
≥ 99.5 % saturation	0.5 mGy
≥ 99.0 % saturation	1.0 mGy

Ranges of use

Chamber voltage	±(100 ... 400) V
Radiation quality	140 kV ... 50 MV photons (10 ... 45) MeV electrons (50 ... 270) MeV protons
Field size	(3 x 3) cm² ... (40 x 40) cm²
Temperature	(10 ... 40) °C (50 ... 104) °F
Humidity	(10 ... 80) %, max 20 g/m³
Air pressure	(700 ... 1060) hPa

Ordering Information

TN31010 Semiflex chamber 0.125 cm³, connecting system BNT
TW31010 Semiflex chamber 0.125 cm³, connecting system TNC
TM31010 Semiflex chamber 0.125 cm³, connecting system M

Options

T48012 Radioactive check device ^{90}Sr
T48002.1.004 Chamber holding device for check device
T40072.1.160 RUBY detector holder T31010

Semiflex Chamber 0.3 cm^3 Type 31013

Therapy chamber for scanning systems and for reference dosimetry

- Waterproof, semiflexible design for easy mounting in scanning water phantoms
- Increased sensitive volume for low level measurements
- Sensitive volume of 0.3 cm^3, vented

The 31013 semiflexible chamber is ideal for precise dose measurements and for the measurement of dose distributions in scanning water phantom systems. The chamber is used as an alternative for the 31010 chamber in cases where increased signal levels are required and spatial resolution along the axis of the chamber can be compromised.

General

Type of product	vented cylindrical ionization chamber
Application	reference dosimetry in radiotherapy beams
Measuring quantities	absorbed dose to water, air kerma, exposure
Reference radiation quality	^{60}Co
Design	waterproof, vented, guarded
Direction of incidence	radial

Specification

Nominal sensitive volume	0.3 cm^3
Nominal response	10 nC/Gy
Long-term stability	≤ 1 % per year
Chamber voltage	400 V nominal ±500 V maximal
Polarity effect at ^{60}Co	< 1 %
Reference point	on chamber axis, 9.5 mm from chamber tip
Photon energy response	≤ ±2 % (140 kV ... 280 kV) ≤ ±4 % (100 kV ... ^{60}Co)
Directional response in water	≤ ±0.5 % for rotation around the chamber axis ≤ ±0.1 % for tilting of the axis up to ±10°
Leakage current	≤ ±4 fA
Cable leakage	≤ 1 pC/(Gy·cm)

Materials and measures

Wall of sensitive volume	0.55 mm PMMA, 1.19 g/cm^3 0.15 mm graphite, 0.82 g/cm^3
Total wall area density	78 mg/cm^2
Dimensions of sensitive volume	radius 2.75 mm length 16.25 mm
Central electrode	Al 99.98, diameter 0.9 mm
Build-up cap	PMMA, thickness 3 mm

Ion collection efficiency at nominal voltage

Ion collection time	121 µs
Max. dose rate for	
≥ 99.5 % saturation	6 Gy/s
≥ 99.0 % saturation	13 Gy/s
Max. dose per pulse for	
≥ 99.5 % saturation	0.5 mGy
≥ 99.0 % saturation	1.0 mGy

Ranges of use

Chamber voltage	±(100 ... 400) V
Radiation quality	100 kV ... 50 MV photons (10 ... 45) MeV electrons (50 ... 270) MeV protons
Field size	(4 x 4) cm^2 ... (40 x 40) cm^2
Temperature	(10 ... 40) °C (50 ... 104) °F
Humidity	(10 ... 80) %, max 20 g/m^3
Air pressure	(700 ... 1060) hPa

Ordering Information

TN31013 Semiflex chamber 0.3 cm^3, connecting system BNT
TW31013 Semiflex chamber 0.3 cm^3, connecting system TNC
TM31013 Semiflex chamber 0.3 cm^3, connecting system M

Options

T48012	Radioactive check device ^{90}Sr
T48002.1.004	Chamber holding device for check device

PinPoint® 3D Chamber 0.016 cm^3 Type 31022

Ultra small-sized therapy chamber with 3D characteristics for dosimetry in high-energy photon beam

- Small polarity effect
- Minimal cable irradiation effect
- Short ion collection time
- Large field size range
- Point dose patient QA with RUBY

The 31022 PinPoint 3D chamber is ideal for measurements in small fields but can also be used for measurements in large fields. Designed for radial beam orientation, the small-sized chamber shows excellent 3D characteristics. Relative dose distributions can be measured with high spatial resolution in any direction. It is waterproof and guarded, thus it can be used in air, solid state phantoms and in water.

General

Type of product	vented cylindrical ionization chamber
Application	dosimetry in high-energy photon beams
Measuring quantities	absorbed dose to water, air kerma, exposure
Reference radiation quality	^{60}Co
Design	waterproof, vented, guarded
Direction of incidence	radial, axial

Specification

Nominal sensitive volume	0.016 cm^3
Nominal response	400 pC/Gy
Long-term stability	≤ 0.5 % over year
Chamber voltage	300 V nominal ±500 V maximal
Polarity effect ^{60}Co	≤ ±0.8 %
Reference point	on chamber axis, 2.4 mm from chamber tip
Directional response in water	≤ ±0.5 % for rotation around the chamber axis, ≤ ±1 % for tilting of the axis up to ±10°
Leakage current	≤ ±4 fA
Cable leakage	≤ 100 fC/(Gy·cm)

Materials and measures

Wall of sensitive volume	0.57 mm PMMA, 1.19 g/cm^3 0.09 mm graphite, 1.85 g/cm^3
Total wall area density	84 mg/cm^2
Dimensions of sensitive volume	radius 1.45 mm length 2.9 mm
Central electrode	Al 99.98, diameter 0.6 mm
Build-up cap	PMMA, thickness 3 mm

Ion collection efficiency at nominal voltage

Ion collection time	45 µs
Max. dose rate for	
≥ 99.5 % saturation	46 Gy/s
≥ 99.0 % saturation	91 Gy/s
Max. dose per pulse for	
≥ 99.5 % saturation	0.8 mGy
≥ 99.0 % saturation	2.2 mGy

Ranges of use

Chamber voltage	±(100 ... 400) V
Radiation quality	^{60}Co ... 25 MV photons
Field size	(2 x 2) cm^2 ... (40 x 40) cm^2
Small fields[1]	down to 0.8 cm
Temperature	(10 ... 40) °C (50 ... 104) °F
Humidity	(10 ... 80) %, max 20 g/m^3
Air pressure	(700 ... 1060) hPa

Ordering Information

TN31022 PinPoint 3D chamber 0.016 cm^3, connecting system BNT
TW31022 PinPoint 3D chamber 0.016 cm^3, connecting system TNC
TM31022 PinPoint 3D chamber 0.016 cm^3, connecting system M

Options

T48012 Radioactive check device ^{90}Sr
T48002.1.010 Chamber holding device for check device
T40072.1.120 RUBY detector holder T31022

[1]This detector is well suited for measurements in small and very small fields. Please note that for high accuracy measurements any detector may need correction factors in small fields. The small field size limit is provided as equivalent square field size following the methodology of IAEA TRS-483:2017. In accordance with TRS-483, the smallest field size considered is 0.4 cm.

PinPoint® 3D MR Chamber 0.016 cm³ Type 31025

Ready for use ultra small-sized MR conditional chamber with optimized MR imaging features and 3D characteristics

- Particularly suited for End2End testing of gating algorithm
- MR conditional (ASTM F2052-15 & ASTM F2213-17)
- Small polarity effect
- Minimal cable irradiation effect
- Short ion collection time
- Suitable for field sizes from 2 cm x 2 cm to 40 cm x 40 cm
- Small-sized cylindrical ion chamber with vented sensitive volume of only 0.016 cm³

The 31025 PinPoint 3D MR chamber is ideal for measurements in an MR environment encountered e.g. at MR-Linacs such as MRidian Viewray and ELEKTA Unity. Designed for radial beam orientation, the small-sized chamber shows excellent 3D characteristics. Relative dose distributions can be measured with high spatial resolution in any direction. It is waterproof and guarded, thus it can be used in air, solid state phantoms and in water.

General

Type of product	vented cylindrical ionization chamber
Application	dosimetry in high-energy photon beams
Measuring quantities	absorbed dose to water, air kerma, exposure
Reference radiation quality	^{60}Co
Design	waterproof, vented, guarded
Direction of incidence	radial, axial

Specification

Nominal sensitive volume	0.016 cm³
Nominal response	400 pC/Gy
Long-term stability	≤ 0.5 % over year
Chamber voltage	300 V nominal ±500 V maximal
Polarity effect ^{60}Co	≤ ±0.8 %
Reference point	on chamber axis, 2.4 mm from chamber tip
Directional response in water	≤ ±0.5 % for rotation around the chamber axis, ≤ ±1 % for tilting of the axis up to ±10°
Leakage current	≤ ±4 fA
Cable leakage	≤ 100 fC/(Gy·cm)

Materials and measures

Wall of sensitive volume	0.57 mm PMMA, 1.19 g/cm³ 0.09 mm graphite, 1.85 g/cm³
Total wall area density	84 mg/cm²
Dimensions of sensitive volume	radius 1.45 mm length 2.9 mm
Central electrode	Al 99.98, diameter 0.6 mm
Build-up cap	PMMA, thickness 3 mm

Ion collection efficiency at nominal voltage

Ion collection time	45 µs
Max. dose rate for	
≥ 99.5 % saturation	46 Gy/s
≥ 99.0 % saturation	91 Gy/s
Max. dose per pulse for	
≥ 99.5 % saturation	0.8 mGy
≥ 99.0 % saturation	2.2 mGy

Ranges of use

Chamber voltage	±(100 ... 400) V
Radiation quality	^{60}Co ... 25 MV photons
Field size	(2 x 2) cm² ... (40 x 40) cm²
Small fields[1]	down to 0.8 cm
Temperature	(10 ... 40) °C (50 ... 104) °F
Humidity	(10 ... 80) %, max 20 g/m³
Air pressure	(700 ... 1060) hPa

Ordering Information

TW31025 PinPoint 3D MR chamber 0.016 cm³, connecting system TNC

[1]This detector is well suited for measurements in small and very small fields. Please note that for high accuracy measurements any detector may need correction factors in small fields. The small field size limit is provided as equivalent square field size following the methodology of IAEA TRS-483:2017. In accordance with TRS-483, the smallest field size considered is 0.4 cm.

PinPoint® Chamber 0.03 cm^3 Type 31015

Small-sized therapy chamber for dosimetry in high-energy photon beams

- Small-sized sensitive volume of only 0.03 cm^3 and 2.9 mm in diameter, vented
- Very high spatial resolution when used for scans perpendicular to the chamber axis
- Aluminum central electrode

The 31015 PinPoint chamber is ideal for dose measurements in small fields as encountered e.g. in IORT, IMRT and stereotactic beams. Relative dose distributions can be measured with very high spatial resolution when the chamber is moved perpendicular to the chamber axis.
The waterproof, guarded chamber can be used in air, solid state phantoms and in waterproof.

General

Type of product	vented cylindrical ionization chamber
Application	dosimetry in high-energy photon beams
Measuring quantities	absorbed dose to water, air kerma, exposure
Reference radiation quality	^{60}Co
Design	waterproof, vented, guarded
Direction of incidence	radial, axial

Specification

Nominal sensitive volume	0.03 cm^3
Nominal response	800 pC/Gy
Long-term stability	≤ 1 % per year
Chamber voltage	400 V nominal ±500 V maximal
Polarity effect	≤ ±2 %
Reference point	on chamber axis, 3.4 mm from chamber tip
Directional response in water	≤ ±0.5 % for rotation around the chamber axis, ≤ ±1 % for tilting of the axis up to ±20° (radial incidence) ±15° (axial incidence)
Leakage current	≤ ±4 fA
Cable leakage	≤ 1 pC/(Gy·cm)

Materials and measures

Wall of sensitive volume	0.57 mm PMMA, 1.19 g/cm^3 0.09 mm graphite, 1.85 g/cm^3
Total wall area density	85 mg/cm^2
Dimensions of sensitive volume	radius 1.45 mm length 5 mm
Central electrode	Al 99.98, diameter 0.3 mm
Build-up cap	PMMA, thickness 3 mm

Ion collection efficiency at nominal voltage

Ion collection time	43 µs
Max. dose rate for	
≥ 99.5 % saturation	29 Gy/s
≥ 99.0 % saturation	55 Gy/s
Max. dose per pulse for	
≥ 99.5 % saturation	1.2 mGy
≥ 99.0 % saturation	2.3 mGy

Ranges of use

Chamber voltage	±(100 ... 400) V
Radiation quality	^{60}Co ... 50 MV photons
Field size	(2 x 2) cm^2 ... (30 x 30) cm^2
Temperature	(10 ... 40) °C (50 ... 104) °F
Humidity	(10 ... 80) %, max 20 g/m^3
Air pressure	(700 ... 1060) hPa

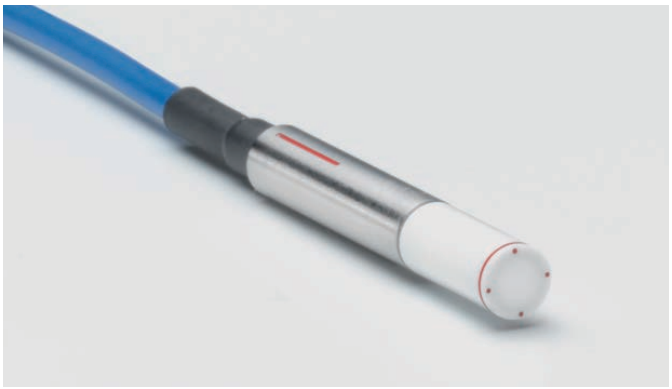
Ordering Information

TN31015 PinPoint chamber 0.03 cm^3, connecting system BNT
TW31015 PinPoint chamber 0.03 cm^3, connecting system TNC
TM31015 PinPoint chamber 0.03 cm^3, connecting system M

Options

T48012	Radioactive check device ^{90}Sr
T48002.1.007	Chamber holding device for check device

microSilicon Type 60023



Waterproof silicon detector for dosimetry in high energy electron and photon beams

- Useful for measurements in all electron fields and for photon fields ≤ (10 x 10) cm²
- Excellent spatial resolution
- Thin entrance window for measurements in the vicinity of surfaces and interfaces
- Very small detector to detector variation
- Excellent dose stability
- Very low dose per pulse dependence
- Point dose patient QA with RUBY

The microSilicon is ideal for dose measurements in electron and small photon fields. The excellent spatial resolution makes it possible to measure very precisely beam profiles even in the penumbra region of small fields. The microSilicon is recommended for dose measurements in all electron fields and for photon fields up to (10 x 10) cm². The waterproof detector can be used in air and in water.
The microSilicon shows a very small detector to detector variation which provides a sound basis for reliable small field correction factors.

General

Type of product	p-type silicon diode
Application	relative dosimetry in radiotherapy beams
Reference radiation quality	^{60}Co
Design	waterproof, disk-shaped sensitive volume perpendicular to detector axis
Direction of incidence	axial

Specification

Nominal sensitive volume	0.03 mm³
Nominal response	19 nC/Gy
Dose stability	
Electrons	≤ 0.5 %/kGy at 10 MeV
	≤ 1 %/kGy at 21 MeV
Photons	≤ 0.1 %/kGy at 6 MV
	≤ 0.5 %/kGy at 18 MV
Temperature response	≤ 0.1 %/K typical
Bias voltage	0 V
Signal polarity	negative
Reference point[1]	on detector axis, 0.9 mm from detector tip
Directional response in water	≤ ±1 % for rotation around the detector axis, ≤ ±1 % for tilting of the axis up to ±20°
Leakage current	≤ ±100 fA
Cable leakage	≤ 1 pC/(Gy·cm)

Materials and measures

Entrance window	0.3 mm RW3
	0.01 mm Al
	0.48 mm epoxy
Total window area density	92 mg/cm²
Water-equivalent window thickness	0.9 mm
Dimensions of sensitive volume	radius 0.75 mm
	thickness 18 µm
Outer dimensions	diameter 7 mm
	length 45.5 mm

Ranges of use

Radiation quality	(6 ... 25) MeV electrons
	^{60}Co ... 25 MV photons
Field size	(1 x 1) cm² ... (40 x 40) cm² for electrons
	(1 x 1) cm² ... (10 x 10) cm² for photons
Small fields[2]	down to 0.4 cm
Temperature	(10 ... 40) °C
	(50 ... 104) °F
Humidity	(10 ... 80) %, max 20 g/m³
Air pressure	(700 ... 1060) hPa

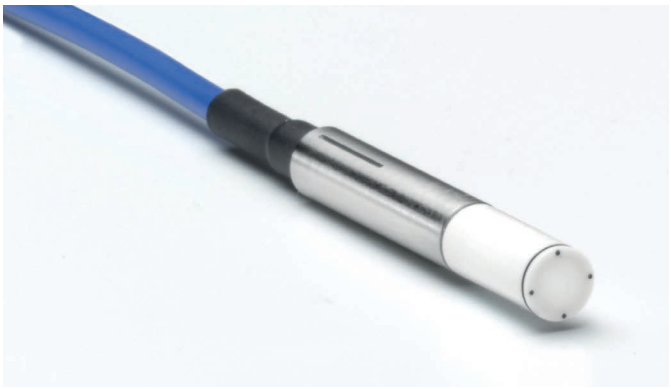
Ordering Information

TN60023 microSilicon, connecting system BNT
TW60023 microSilicon, connecting system TNC
TM60023 microSilicon, connecting system M
T40072.1.140 RUBY detector holder T60023

[1]Photons: Reference point corresponds to the effective point of measurement.
Electrons: Effective point of measurement is 0.3 mm from tip.

[2]This detector is well suited for measurements in small and very small fields. Please note that for high accuracy measurements any detector may need correction factors in small fields. The small field size limit is provided as equivalent square field size following the methodology of IAEA TRS-483:2017. In accordance with TRS-483, the smallest field size considered is 0.4 cm.

microSilicon X
Type 60022



Shielded silicon diode detector for all photon fields

- Shielded diode detector for photon field sizes up to (40 x 40) cm^2
- The shielding reduces the low energy scattered radiation amount in the detector signal
- Ideal for percentage depth dose measurements, field size independent
- Excellent dose stability (≤ 0.1 %/kGy at 6 MV)
- Very low dose per pulse dependence

Due to its newly developed shielding, the microSilicon X is perfectly suited for measurements in photon fields up to large field sizes. With its excellent spatial resolution, it is possible to measure very precisely beam profiles, even in the penumbra region.
The improved energy response enables the user to perform accurate, field size independent percentage depth dose measurements. In addition the new design results in a small water equivalent window thickness, which has positive effects on the measurements of output factors.

General

Type of product	shielded p-type silicon diode
Application	relative dosimetry in high-energy photon beams
Reference radiation quality	^{60}Co
Design	waterproof, disk-shaped sensitive volume perpendicular to detector axis
Direction of incidence	axial

Specification

Nominal sensitive volume	0.03 mm^3
Nominal response	19 nC/Gy
Dose stability	≤ 0.1 %/kGy at 6 MV ≤ 0.5 %/kGy at 18 MV
Temperature response	≤ 0.1 %/K typical
Bias voltage	0 V
Signal polarity	negative
Reference point[1]	on detector axis, 0.9 mm from detector tip
Directional response in water	≤ ±1 % for rotation around the detector axis, ≤ ±1 % for tilting of the axis up to ±20°
Leakage current	≤ ±100 fA
Cable leakage	≤ 1 pC/(Gy·cm)

Materials and measures

Entrance window	0.3 mm RW3 0.01 mm Al 0.48 mm epoxy
Total window area density	92 mg/cm^2
Water-equivalent window thickness	0.9 mm
Dimensions of sensitive volume	radius 0.75 mm thickness 18 µm
Outer dimensions	diameter 7 mm length 45.5 mm

Ranges of use

Radiation quality	^{60}Co ... 25 MV photons
Field size	(2 x 2) cm^2 ... (40 x 40) cm^2
Temperature	(10 ... 40) °C (50 ... 104) °F
Humidity	(10 ... 80) %, max 20 g/m^3
Air pressure	(700 ... 1060) hPa

Ordering Information

TN60022 microSilicon X, connecting system BNT
TW60022 microSilicon X, connecting system TNC
TM60022 microSilicon X, connecting system M

[1]Reference point corresponds to the effective point of measurement.

microDiamond®
Type 60019

As stable as a diamond, as sensitive as a diode - the microDiamond detector is the ideal detector for a broad range of radiotherapy applications

- Perfectly suited for small and very small fields
- Excellent spatial resolution for accurate penumbra measurements
- Nearly water-equivalence
- Outstanding radiation hardness
- Negligible dose-rate and dose-per-pulse dependence
- Point dose patient QA with RUBY

The microDiamond is a synthetic diamond detector which is well characterized, unique, and versatile for high-precision dosimetry in high-energy photon, electron, proton and carbon ion beams. This all-in-one detector is the perfect detector for small and very small field dosimetry, as well as large field dosimetry. With the versatile microDiamond, you will never have to worry about choosing the right detector again.

General

Type of product	synthetic single crystal diamond detector
Application	relative dosimetry on radiotherapy beams
Reference radiation quality	^{60}Co
Design	waterproof, disk-shaped, sensitive volume perpendicular to detector axis
Direction of incidence	axial

Specification

Nominal sensitive volume	0.004 mm^3
Nominal response	1 nC/Gy
Long-term stability	≤ 0.5 % per year
Dose Stability	≤ 0.25 %/kGy at 18 MV
Temperature response	≤ 0.08 %/K
Energy response	at higher depths than d_{max}, the percentage depth dose curves match curves measured with ionization chambers within ±0.5 %
Bias voltage	0 V
Signal polarity	positive
Reference point	on detector axis, 1 mm from detector tip
Photon energy response	≤ ±2 % (140 kV ... 280 kV) ≤ ±4 % (100 kV ... ^{60}Co)
Directional response in	≤ ±1 % for tilting ≤ ±10°
Leakage[1] current	≤ ±20 fA
Cable leakage	≤ 200 pC/(Gy·cm)

Materials and measures

Entrance window	0.3 mm RW3 0.6 mm Epoxy 0.01 mm Al 99.5
Total window area density	0.1 g/cm^2
Water-equivalent window thickness	1.0 mm
Sensitive volume	radius 1.1 mm, circular thickness 1 µm
Outer dimensions	diameter 7 mm length 45.5 mm

Ranges of use

Radiation quality	100 keV ... 50 MV photons (6 ... 25) MeV electrons (70 ... 230) MeV protons (115 ... 380) MeV/u carbon ions[2]
Field size	(1 x 1) cm^2 ... (40 x 40) cm^2
Small fields[3]	down to 0.4 cm
Temperature	(10 ... 35) °C (50 ... 95) °F
Humidity	(10 ... 80) %, max 20 g/m^3

Ordering Information

TN60019 microDiamond, connecting system BNT
TW60019 microDiamond, connecting system TNC
TM60019 microDiamond, connecting system M
T40072.1.110 RUBY detector holder T60019

The microDiamond detector is realized in collaboration with Marco Marinelli and Glanluca Verona-Rinati and their team, Industrial engineering Department of Rome Tor Vergata University, Italy.

[1] I. Ciancaglionii, M. Marinelli, E. Milani, G. Prestopino, C. Verona, G. Verona-Ronati, R. Consroti, A. Petrucci and F. De Norariстefani, Dosimetric characterization of a synthetic single crystal diamond detector in clinical radiation therapy small photon beams, Med. Phys. 39 (2012), 4493

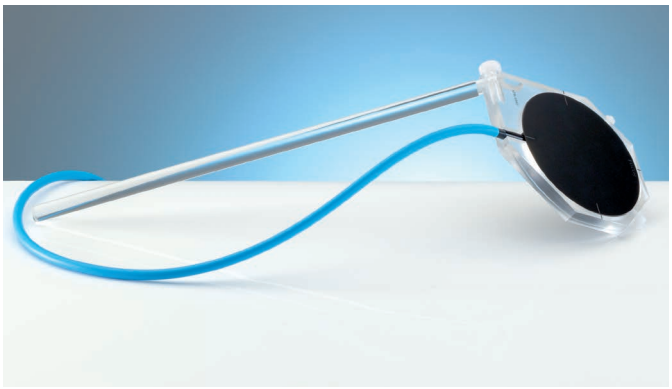
[2] C. Di Venanzio, M. Marinelli, E. Milani, G. Prestopino, C-Verona, G. Verona-Rinati, M. D. Falco, P. Bagalà, R- Santoni and M. Pimpinella, Characterization of a synthetic single crystal diamond Schottky diode for radiotherapy electron beam dosimetry, Med. Phys. 40 (2013), 021712

[1]At the high end of the temperature range, higher leakage currents may occur.

[2]In rare cases, an individual mircoDiamond can exhibit an LET dependence in proton or hadron radiation. If you suspect that this might be the case for your microDiamond, please contact PTW technical service.

[3]This detector is well suited for measurements in small and very small fields. Please note that for high accuray measurements any detector may need correction factors in small fields. The small field size limit is provided as equivalent square field size following the methodology of IAEA TRS-483:2017. In accordance with TRS-483, the smallest field size considered is 0.4 cm.

T-REF Chamber Type 34091



Reference detector for small fields

- Very low total area density of 72 mg/cm²
- No measurable perturbation of the beam
- High and very stable signal
- No contact to linac head
- Fast and easy to mount

The T-REF chamber 34091 provides a solution to the problem where to put a reference detector in small fields. The T-REF chamber is an easy-to-use large-area plane-parallel transmission reference chamber. From the minimum distance to the water surface on, there are no measurable perturbations of the beam. The very good signal-to-noise-ratio makes it an excellent option for use as a reference detector.

General

Type of product	vented plane-parallel ionization chamber
Application	reference for relative dosimetry in high-energy small field photon beams
Design	waterproof, vented, guarded, perturbation-free
Direction of incidence	perpendicular to the entrance window, see label "Focus"

Specification

Nominal sensitive volume	10.5 cm³
Nominal response	325 nC/Gy (at ^{60}Co free in air)
Chamber voltage	400 V nominal ±500 V maxima
Polarity effect	≤ ±1 %
Reference point	inner surface of the entrance window, at the center of the window
Leakage current	≤ ±100 fA
Cable leakage	≤ 1 pC/(Gy·cm)

Materials and measures

Total area density	72 mg/cm²
Water-equivalent window thickness	0.7 mm for photons
Dimension of sensitive volume	radius 40.8 mm depth 2 mm

Ion collection efficiency at nominal voltage

Ion collection time	67 µs
Max. dose rate for	
≥ 99.5 % saturation	21 Gy/s
≥ 99.0 % saturation	42 Gy/s
Max. dose per pulse for	
≥ 99.5 % saturation	0.9 mGy
≥ 99.0 % saturation	1.8 mGy

Ranges of use

Chamber voltage	±(300 ... 400) V
Radiation quality	^{60}Co ... 25 MV photons
Max. field size in 20 cm distance to water surface	(5 x 5) cm²
Temperature	(10 ... 40) °C (50 ... 104) °F
Humidity	(10 ... 80) %, max 20 g/m³
Air pressure	(700 ... 1060) hPa

Ordering Information

TN34091 T-REF chamber, connecting system BNT including holder
TW34091 T-REF chamber, connecting system TNC including holder
TM34091 T-REF chamber, connecting system M including holder

Roos® Chamber Type 34001

Waterproof plane-parallel chamber for reference dosimetry in high-energy electron and proton beams

- Well-guarded (wide guard ring design) in accordance with TRS-398
- Minimized polarity effect
- Waterproof
- Sensitive volume 0.35 cm^3, vented

The 34001 Roos chamber is the golden standard for reference dose measurements in high-energy electron beams. Modern dosimetry protocols refer to the chamber's design and provide dosimetric correction factors. Its waterproof design allows the chamber to be used in water or in solid state phantoms. The Roos chamber is also well suited for the measurement of high-energy photon depth dose curves. The chamber can be used for dose measurements of proton beams.

General

Type of product	vented plane-parallel ionization chamber
Application	reference dosimetry in high-energy electron beams and proton beams
Measuring quantities	absorbed dose to water
Reference radiation quality	^{60}Co
Design	waterproof, vented
Direction of incidence	perpendicular to chamber plane, see label 'Focus'

Specification

Nominal sensitive volume	0.35 cm^3
Nominal response	12 nC/Gy
Long-term stability	≤ 0.5 % per year
Chamber voltage	200 V nominal ±400 V maximal
Polarity effect	< 0.5 %
Reference point	inner surface of the entrance window, at the center of the window or 1.13 mm below surface
Directional response in water	≤ ±0.1 % for chamber tilting ≤ ±10°
Leakage current	≤ ±4 fA
Cable leakage	≤ 1 pC/(Gy·cm)

Materials and measures

Entrance window	1.01 mm PMMA, 1.19 g/cm^3 0.02 mm graphite, 0.44 g/cm^3 0.1 mm laquer, 1.19 g/cm^3
Total window area density	132 mg/cm^2
Water-equivalent window thickness	1.29 mm
Sensitive volume	radius 7.8 mm depth 2 mm
Guard ring width	4 mm

Ion collection efficiency at nominal voltage

Ion collection time	125 µs
Max. dose rate for	
≥ 99.5 % saturation	5.2 Gy/s
≥ 99.0 % saturation	10.4 Gy/s
Max. dose per pulse for	
≥ 99.5 % saturation	0.46 mGy
≥ 99.0 % saturation	0.93 mGy

Ranges of use

Chamber voltage	±(50 ... 300) V
Radiation quality	(2 ... 45) MeV electrons ^{60}Co ... 25 MV photons (50 ... 270) MeV protons
Field size	(4 x 4) cm^2 ... (40 x 40) cm^2
Temperature	(10 ... 40) °C (50 ... 104) °F
Humidity	(10 ... 80) %, max 20 g/m^3
Air pressure	(700 ... 1060) hPa

Ordering Information

TN34001 Roos electron chamber 0.35 cm^3, connecting system BNT
TW34001 Roos electron chamber 0.35 cm^3, connecting system TNC
TM34001 Roos electron chamber 0.35 cm^3, connecting system M

Options

T48012 Radioactive check device ^{90}Sr
T48004 Chamber holding device for check device

Advanced Markus® Chamber Type 34045

Well-guarded plane-parallel chamber for the dosimetry of high-energy electron beams, especially for high dose per pulse values

- Well-guarded in accordance with TRS-398
- Thin entrance window and waterproof protection cap
- Small-sized for high spatial resolution
- Sensitive volume 0.02 cm^3, vented

The 34045 Advanced Markus chamber is the successor of the well-known classic Markus electron chamber, equipped with a wide guard ring for perturbation-free measurements. The thin entrance window allows measurements in solid state phantoms up to the surface. The protection cap makes the chamber waterproof for measurements in water phantoms.

General

Type of product	vented plane-parallel ionization chamber
Application	reference dosimetry in high-energy electron beams
Measuring quantities	absorbed dose to water, air kerma
Reference radiation quality	^{60}Co
Design	waterproof with protection cap, vented, guarded
Direction of incidence	perpendicular to chamber plane

Specification

Nominal sensitive volume	0.02 cm^3
Nominal response	0.67 nC/Gy
Long-term stability	≤ 1 % per year
Chamber voltage	300 V nominal ±400 V maximal
Polarity effect	≤ 1 % for electrons > 9 MeV
Reference point	inner surface of the entrance window, at the center of the window or 1.3 mm below surface of protection cap
Directional response in	≤ ±0.1 % for chamber tilting ≤ ±10°
Leakage current	≤ ±4 fA
Cable leakage	≤ 1 pC/(Gy·cm)

Materials and measures

Entrance foil	0.03 mm PE (polyethylene CH_2), 2.76 mg/cm^2
Protection cap	0.87 mm PMMA, 1.19 g/cm^3, 0.4 mm air
Total window area density	106 mg/cm^2, 1.3 mm (protection cap included)
Water-equivalent window thickness	1.04 mm (protection cap included)
Dimensions of sensitive volume	radius 2.5 mm depth 1 mm
Guard ring width	2 mm

Ion collection efficiency at nominal voltage

Ion collection time	22 µs
Max. dose rate for	
≥ 99.5 % saturation	187 Gy/s
≥ 99.0 % saturation	375 Gy/s
Max. dose per pulse for	
≥ 99.5 % saturation	2.78 mGy
≥ 99.0 % saturation	5.56 mGy

Ranges of use

Chamber voltage	±(50 ... 300) V
Radiation quality	(2 ... 45) MeV electrons (50 ... 270) MeV protons
Field size	(3 x 3) cm^2 ... (40 x 40) cm^2
Temperature	(10 ... 40) °C (50 ... 104) °F
Humidity	(10 ... 80) %, max 20 g/m^3
Air pressure	(700 ... 1060) hPa

Ordering Information

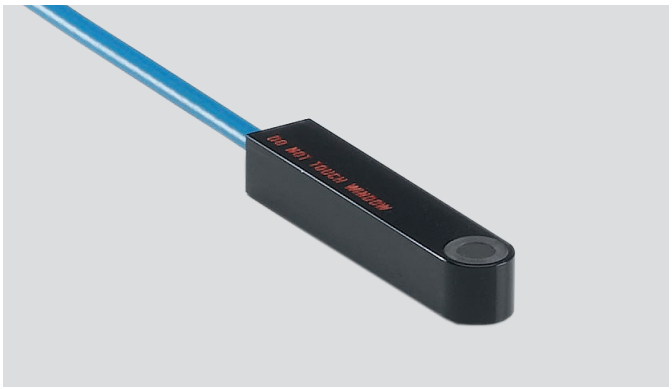
TN34045 Advanced Markus electron chamber, 0.02 cm^3, connecting system BNT
TW34045 Advanced Markus electron chamber, 0.02 cm^3, connecting system TNC
TM34045 Advanced Markus electron chamber, 0.02 cm^3, connecting system M

Options

T48012 Radioactive check device ^{90}Sr
T23343/11Chamber holding device for check device

0.005 cm³ Soft X-Ray Chamber Type 34013

Thin window plane-parallel chamber for dose measurements in superficial radiation therapy



- Ultra thin entrance window
- For low-energy photons from 15 kV to 70 kV
- Extremely small size
- Sensitive volume 0.005 cm³, vented

The 34013 soft X-Ray chamber is used for reference dose measurements in low-energy photon beams as used in superficial radiation therapy. The chamber's small size enables the user to perform measurements with excellent spatial resolution. Correction factors needed for the determination of absorbed dose to water are available. The chamber is designed for the use in solid state phantoms.

General

Type of product	vented plane-parallel ionization chamber
Application	reference dosimetry in low-energy photon beams
Measuring quantities	absorbed dose to water, air kerma, exposure
Reference radiation quality	30 kV, HVL 0.37 mm Al (T30)
Design	not waterproof, vented
Direction of incidence	perpendicular to chamber plane

Specification

Nominal sensitive volume	0.005 cm³
Nominal response	200 pC/Gy
Long-term stability	≤ 1 % per year
Chamber voltage	400 V nominal ±400 V maximal
Reference point	inner surface of the entrance window, at the center of the window
Directional response	≤ ±1 % for tilting by ±5°
Leakage current	≤ ±10 fA
Cable leakage	≤ 1 pC/(Gy·cm)

Materials and measures

Entrance foil	0.03 mm PE
Total window area density	2.76 mg/cm²
Sensitive volume	radius 1.45 mm depth 0.9 mm
Electrode	radius 0.8 mm

Ion collection efficiency at nominal voltage

Ion collection time	14 µs
Max. dose rate for	
≥ 99.5 % saturation	0.5 kGy/s
≥ 99.0 % saturation	1.0 kGy/s
Max. dose per pulse for	
≥ 99.5 % saturation	4.5 mGy
≥ 99.0 % saturation	9.1 mGy

Ranges of use

Chamber voltage	±(100 ... 400) V
Radiation quality	(15 ... 70) kV X-rays
Field size	(0.5 x 0.5) cm² ... (40 x 40) cm²
Temperature	(10 ... 40) °C (50 ... 104) °F
Humidity	(20 ... 80) %, max 20 g/m³
Air pressure	(700 ... 1060) hPa

Ordering Information

TN34013 Soft X-ray chamber 0.005 cm³, connecting system BNT
TW34013 Soft X-ray chamber 0.005 cm³, connecting system TNC
TM34013 Soft X-ray chamber 0.005 cm³, connecting system M

0.02 cm^3 Soft X-Ray Chamber Type 23342

Thin window plane-parallel chamber for dose measurements in superficial radiation therapy

- Ultra thin entrance window
- For low-energy photons from 15 kV to 70 kV
- Sensitive volume 0.02 cm^3, vented

The 23342 soft X-Ray chamber is the golden standard for reference dose measurements in low-energy photon beams as used in superficial radiation therapy. Correction factors needed for the determination of absorbed dose to water are available. The chamber is designed for the use in solid state phantoms.

General

Type of product	vented plane-parallel ionization chamber acc. IEC 60731
Application	reference dosimetry in low-energy photon beams
Measuring quantities	absorbed dose to water, air kerma, exposure
Reference radiation quality	30 kV, HVL 0.37 mm Al (T30)
Design	not waterproof, vented
Direction of incidence	perpendicular to chamber plane

Specification

Nominal sensitive volume	0.02 cm^3
Nominal response	1 pC/Gy
Long-term stability	≤ 1 % per year
Chamber voltage	300 V nominal ±500 V maximal
Reference point	inner surface of the entrance window, at the center of the window
Directional response	≤ ±1 % for chamber tilting up to ±20°
Leakage current	≤ ±10 fA
Cable leakage	≤ 1 pC/(Gy·cm)

Materials and measures

Entrance foil	0.03 mm PE
Total window area density	2.76 mg/cm^2
Sensitive volume	radius 2.55 mm depth 1 mm
Electrode	radius 1.5 mm

Ion collection efficiency at nominal voltage

Ion collection time	22 µs
Max. dose rate for	
≥ 99.5 % saturation	188 kGy/s
≥ 99.0 % saturation	375 kGy/s
Max. dose per pulse for	
≥ 99.5 % saturation	2.8 mGy
≥ 99.0 % saturation	5.6 mGy

Ranges of use

Chamber voltage	±(100 ... 400) V
Radiation quality	(15 ... 70) kV X-rays
Field size	(1 x 1) cm^2 ... (40 x 40) cm^2
Temperature	(10 ... 40) °C (50 ... 104) °F
Humidity	(20 ... 80) %, max 20 g/m^3
Air pressure	(700 ... 1060) hPa

Ordering Information

TN23342 Soft X-ray chamber 0.02 cm^3, connecting system BNT
TW23342 Soft X-ray chamber 0.02 cm^3, connecting system TNC
TM23342 Soft X-ray chamber 0.02 cm^3, connecting system M

Options

T48010	Radioactive check device ^{90}Sr
T23238	Chamber holding device for check device

Bragg Peak® Chamber Type 34070

Waterproof plane-parallel chamber for dosimetry in proton beams

- Waterproof, wide guard ring design
- Sensitive volume 10.5 cm^3

The 34070 Bragg peak chamber is designed to measure the exact location of the Bragg peak in therapy proton beams. The large diameter of the chamber allows the measurement of the complete proton beam diameter (non-scanned) including the scattered protons. The chamber is waterproof and consequently can either be used in air behind a water column or in a water phantom.
In water, the Bragg Peak chamber can be used for measurements of horizontal beams. Due to the thickness of the entrance and exit windows, the chamber can additionally be used in vertical beams where measurements are performed in different water depths.

General

Type of product	vented plane-parallel ionization chamber
Application	relative dosimetry in high-energy proton beams
Design	waterproof, vented, guarded, perturbation free
Direction of incidence	perpendicular to chamber plane, see label 'Focus'

Specification

Nominal sensitive volume	10.5 cm^3
Nominal response	325 nC/Gy (at ^{60}Co free in air)
Chamber voltage	400 V nominal ±500 V maximal
Polarity effect	≤ ±1 %
Reference point	inner surface of the entrance window, at the center of the window or 3.47 mm from chamber surface
Leakage current	≤ ±100 fA
Cable leakage	≤ 1 pC/(Gy·cm)
Cable length	2.5 m

Materials and measures

Entrance window	3.35 mm PMMA 0.02 mm graphite 0.1 mm lacquer
Total window area density	411 mg/cm^2
Water-equivalent window thickness	4 mm
Dimensions of sensitive volume	radius 40.8 mm depth 2 mm

Ion collection efficiency at nominal voltage

Ion collection time	67 µs
Max. dose rate for	
≥ 99.5 % saturation	21 Gy/s
≥ 99.0 % saturation	42 Gy/s
Max. dose per pulse for	
≥ 99.5 % saturation	0.9 mGy
≥ 99.0 % saturation	1.8 mGy

Ranges of use

Chamber voltage	±(300 ... 500) V
Radiation quality	(70 ... 250) MeV protons
Field size	diameter (3 ... 10) mm
Temperature	(10 ... 40) °C (50 ... 104) °F
Humidity	(10 ... 80) %, max 20 g/m^3
Air pressure	(700 ... 1060) hPa

Ordering Information

TN34070-2,5 Bragg peak chamber 10.5 cm^3, connecting system BNT
TW34070-2,5 Bragg peak chamber 10.5 cm^3, connecting system TNC
TM34070-2,5 Bragg peak chamber 10.5 cm^3, connecting system M

Bragg Peak® Chamber Type 34080

Waterproof plane-parallel chamber for dosimetry in proton beams

- Waterproof, wide guard ring design
- Sensitive volume 10.5 cm³

The 34080 Bragg peak chamber is designed to act as a thin window reference chamber in particle therapy dosimetry. The large diameter of the chamber allows the measurement of the complete proton beam diameter (non-scanned) including the scattered protons. The chamber is waterproof but pressure sensitive. It can be used in air or at the water surface of a water phantom..

General

Type of product	vented plane-parallel ionization chamber
Application	relative dosimetry in high-energy proton beams
Design	waterproof, vented, guarded, perturbation free
Direction of incidence	perpendicular to chamber plane, see label 'Focus'

Specification

Nominal sensitive volume	10.5 cm³
Nominal response	325 nC/Gy (at ^{60}Co free in air)
Chamber voltage	400 V nominal ±500 V maximal
Polarity effect	≤ ±1 %
Reference point	inner surface of the entrance window, at the center of the window or 0.62 mm from chamber surface
Leakage current	≤ ±100 fA
Cable leakage	≤ 1 pC/(Gy·cm)
Cable length	2.5 m

Materials and measures

Entrance window	0.5 mm PMMA 0.02 mm graphite 0.1 mm lacquer
Total window area density	72 mg/cm²
Water-equivalent window thickness	0.7 mm
Total layers	1.5 mm PMMA 0.08 mm graphite 0.2 mm lacquer
Total area density	205 mg/cm²
Total water-equivalent thickness	2.1 mm
Dimensions of sensitive volume	radius 40.8 mm depth 2 mm

Ion collection efficiency at nominal voltage

Ion collection time	67 µs
Max. dose rate for	
≥ 99.5 % saturation	21 Gy/s
≥ 99.0 % saturation	42 Gy/s
Max. dose per pulse for	
≥ 99.5 % saturation	0.9 mGy
≥ 99.0 % saturation	1.8 mGy

Ranges of use

Chamber voltage	±(300 ... 500) V
Radiation quality	(70 ... 250) MeV protons
Field size	diameter (3 ... 10) mm
Temperature	(10 ... 40) °C (50 ... 104) °F
Humidity	(10 ... 80) %, max 20 g/m³
Air pressure	(700 ... 1060) hPa

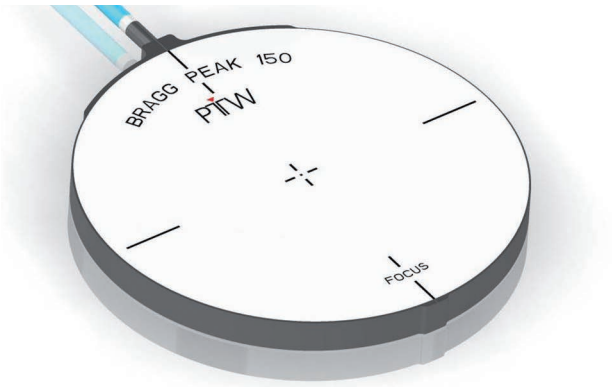
Ordering Information

TN34080-2,5 Bragg peak chamber 10.5 cm³, connecting system BNT

TW34080-2,5 Bragg peak chamber 10.5 cm³, connecting system TNC

TM34080-2,5 Bragg peak chamber 10.5 cm³, connecting system M

Bragg Peak® 150
Type 34089



Very large area plane-parallel chamber for dosimetry in proton beams

- Waterproof, wide guard ring design
- Sensitive volume 34 cm³, vented
- Very large diameter

The 34089 Bragg peak chamber is designed to measure the exact location of the Bragg peak in therapy proton beams. The very large diameter of the chamber allows the measurement of the proton pencil beam diameter including the beam halo. The chamber is waterproof and consequently can either be used in air behind a water column or in a water phantom. In water, the Bragg Peak chamber can be used for measurements of horizontal beams. Due to the thickness of the entrance and exit windows, the chamber can additionally be used in vertical beams where measurements are performed in different water depths.

General

Type of product	vented plane-parallel ionization chamber
Application	relative dosimetry in high-energy proton beams
Design	waterproof, vented, guarded
Direction of incidence	perpendicular to chamber plane, see label 'Focus'

Specification

Nominal sensitive volume	34 cm³
Nominal response	1.24 µC/Gy (at ^{60}Co free in air)
Chamber voltage	400 V nominal ±500 V maximal
Polarity effect	≤ ±1 %
Reference point	inner surface of the entrance window, at the center of the window
Leakage current	≤ ±250 fA
Cable leakage	≤ 1 pC/(Gy·cm)
Cable length	2.5 m

Materials and measures

Entrance window	0.29 mm PC foil 0.1 mm GFRP 2.47 mm CFRP 0.03 mm graphite
Total window area density	465 mg/cm²
Water-equivalent window thickness	4.65 mm
Dimensions of sensitive volume	radius 73.5 mm depth 2 mm

Ion collection efficiency at nominal voltage

Ion collection time	67 µs
Max. dose rate for	
≥ 99.5 % saturation	21 Gy/s
≥ 99.0 % saturation	42 Gy/s
Max. dose per pulse for	
≥ 99.5 % saturation	0.9 mGy
≥ 99.0 % saturation	1.8 mGy

Ranges of use

Chamber voltage	±(100 ... 400) V
Radiation quality	(70 ... 250) MeV protons
Field size	diameter (3 ... 10) mm
Temperature	(15 ... 35) °C (59 ... 95) °F
Humidity	(10 ... 80) %, max 20 g/m³
Air pressure	(540 ... 1060) hPa

Ordering Information

TN34089 Bragg Peak 150, connecting system BNT
TW34089 Bragg Peak 150, connecting system TNC
TM34089 Bragg Peak 150, connecting system M

SOURCECHECK 4π Type 33005

Ionization chamber for measuring the source strength of radioactive seeds and intravascular brachytherapy sources

- Measures low energy seeds and high energy afterloading sources
- Measures all sources in a full 4π geometry
  Adapters for all commercial afterloading devices and seeds
- User friendly accessories for fast and safe handling
- Compatible to reference class PTW dosemeters
- Calibration for Ir-192, Co-60 and I-125 available

The SOURCECHECK 4π well-type ionization chamber is suitable for source strength measurements of all kind of brachytherapy sources. International standards require the measurement of radioactive brachytherapy sources. For HDR afterloading sources an acceptance test after the replacement of the source and additional constancy checks are required. For permanent implanted seeds the typical quality assurance is measuring a defined amount seeds out of a delivered batch.
Various adapters for all kind of afterloading applicators and for different seeds and seed strands are available. The radioactive check source T48010 can be used for constancy checks. The chamber can be calibrated for Ir-192, Co-60 and I-125.

General

Type of product	well-type ionization chamber
Application	source strength measurement of brachytherapy sources
Measuring quantities	apparent activity, air kerma strength, exposure strength, reference air kerma rate
Calibration	Ir-192, Co-60, I-125, others upon request
Design	vented, guarded

Specification

Nominal volume	116 cm^3
Nominal response	125 fA/MBq (Ir-192) 65 fA/MBq (I-125)
Long-term stability	≤ ±1 % per year
Chamber voltage	400 V nominal ±500 V maximal
Reference point	95 mm below chamber top (Ir-192)
Leakage current	≤ ±50 fA

Measures

Inner well diameter	32 mm
Outer dimensions	height 182 mm base diameter 127 mm outer well diameter 93 mm
Weight	1.4 kg

Ranges of use

Temperature	(10 ... 40) °C for sources > 100 keV photons (15 ... 35) °C for sources < 100 keV photons or < 1 MeV electrons
Humidity	(10 ... 80) %, max 20 g/m^3
Air pressure	(700 ... 1060) hPa

Ordering Information

TN33005 SOURCECHECK 4π, connecting system BNT
TW33005 SOURCECHECK 4π, connecting system TNC
TM33005 SOURCECHECK 4π, connecting system M

Options

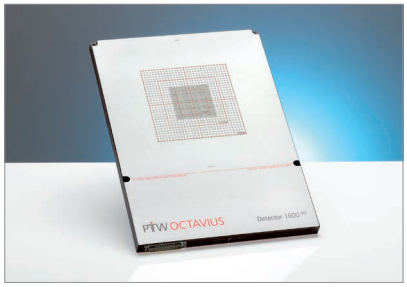
T33004.1.012 HDR Universal Adapter 1.0 – 1.8 mm
T33004.1.013 HDR Universal Adapter 1.8 – 3.2 mm
T33004.1.014 HDR Universal Adapter 3.2 – 4.6 mm
T33004.1.015 HDR Universal Adapter 4.5 – 5.9 mm
T33004.1.016 HDR Universal Adapter 5.8 – 7.2 mm
T33002.1.009 Adapter for Nucletron AL
T33005.1.100 SOURCECHECK single seed adapter
T33005.1.150 SOURCECHECK seed adapter Nucletron
T33005.1.130 SOURCECHECK strand adapter
T33005.1.120 SOURCECHECK Rapid Strand adapter
T33005.1.160 SOURCECHECK Valencia-Leipzig adapter
T33005.1.020 SOURCECHECK radioactive check source adapter
T48010 Check device 90-Sr, point source
E21272 SOURCECHECK calibration Ir-192
E21271 SOURCECHECK calibration I-125

Array Detectors for Radiotherapy

Our array detectors are also available as MR version for measurements in an MR environment or as XDR version for particle therapy.

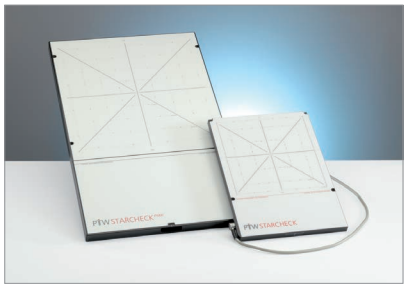
OCTAVIUS® Detector 1500

The OCTAVIUS Detector 1500 is an array detector for patient plan verification and quality control in radiation therapy. The center-to-center spacing is 7.1 mm. In total there are located 1405 ion chambers in a chessboard matrix, providing a maximum field size of 27 cm x 27 cm. Combined with the OCTAVIUS 4D phantom, this makes the detector to a good solution for independent 3D dose distribution measurments of large treatment plans.



OCTAVIUS® Detector 1600 SRS

The OCTAVIUS Detector 1600 SRS allows 2D patient plan verification and, when combined with OCTAVIUS 4D, independent 3D patient plan verification. Due to its high spatial resolution (2.5 mm) and its large detector area of 15 x 15 cm^2 OCTAVIUS 1600 SRS allows patient specific QA of SRS treatments, especially of those including multiple, widely spaced target volumes even in different planes.



STARCHECK® and STARCHECK maxi

STARCHECK is a precise and reliable tool for fast measurements in radiation therapy beams. Typical applications are quality control and Linac beam adjustment measurements with the detector panel embedded in a solid state phantom. STARCHECK maxi has been designed especially for measurements of high-resolution star profiles for radiation fields up to 40 x 40 cm.

Radioactive ^{90}Sr Check Devices

Radioactive check devices are used for air density corrections of vented ionization chambers or for constancy checks of the complete dosemeters including chamber. Appropraite holding devices are available.

Check Devices for Ion Chambers

The check device type T48012 is specially designed for thimble chambers, the check device type T48010 for flat chambers. Both include an encapsulated ^{90}Sr source with a low activity. The source are equivalent to ISO class C64444.

Diagnostic Detectors

- CT Chamber 3.14 cm^3 44
- CT Chamber 9.3 cm^3 45
- SFD Chamber 75 cm^3 46
- SFD Chamber 6 cm^3 47
- System Incorporated Detectors 48

CT Chamber Type 30009

Vented cylindrical pencil chamber for dose length product measurements in computed tomography

- Pencil type chamber for measurements within a CT head or body phantom or free in air
- Provides a sensitive measuring length of 10 cm
- Shows a homogeneous response over the whole chamber length

The CT chamber is a vented cylinder chamber designed for dose length product and dose length product rate measurements in computed tomo graphy. The chamber allows the determination of the CTDI100[1], CTDIW[2] and CTDIVol[3] according to IEC 61223-2-6 and IEC 61223-3-5.

General

Type of product	vented pencil type chamber
Application	dosimetry in computed tomography
Measuring quantities	air kerma length product, exposure length product
Reference radiation quality	120 kV, HVL 8.4 mm Al (RQT9)
Design	not waterproof, vented, pencil type

Specification

Nominal sensitive volume	3.14 cm^3
Nominal response	14 nC/(Gy·cm)
Reference point	chamber center
Direction of incidence	radial
Chamber voltage	-100 V nominal ±500 V maximal high voltage to be connected only with active current-limiting device (Imax < 0.5 mA)
Energy response	≤ ±5 % for (70 ... 150) kV
Leakage current	≤ ±10 fA
Cable leakage	≤ 1 pC/(Gy·cm)

Materials and measures

Wall material	1 mm PMMA, graphite coated
Wall area density	119 mg/cm^2
Dimensions of sensitive	radius 3.5 mm volume length 100 mm
Electrode	Al tube, graphited outer diameter 3 mm

Ion collection efficiency at nominal voltage

Ion collection time	274 µs
Max. dose rate for ≥ 95.0 % saturation	12.4 Gy/s
Max. dose per pulse for ≥ 95.0 % saturation	2.2 mGy

Ranges of use

Chamber voltage	±(100 ... 400) V
Radiation quality	(50 ... 150) kV
Temperature	(10 ... 40) °C (50 ... 104) °F
Humidity	(10 ... 80) %, max 20 g/m^3
Air pressure	(700 ... 1060) hPa

Ordering Information

TN30009 CT chamber 3.14 cm^3, connecting system BNT
TW30009 CT chamber 3.14 cm^3, connecting system TNC
TM30009 CT chamber 3.14 cm^3, connecting system M
TL30009 CT chamber 3.14 cm^3, connecting system L

[1]CTDI100 = Computed Tomography Dose Index 100
[2]CTDIW = Weighted CTDI100
[3]CTDIVol = Volume CTDIW

CT Chamber Type 30017

Vented cylindrical pencil chamber for dose length product measurements in computed tomography

- Pencil type chamber for measurements free in air
- Provides a sensitive measuring length of 30 cm
- Shows a homogeneous response over the whole chamber length

The CT chamber is a vented cylinder chamber designed for dose length product and dose length product rate measurements in computed tomo graphy according to the amendment to IEC 60601-2-44.

General

Type of product	vented pencil type chamber
Application	dosimetry in computed tomography
Measuring quantities	air kerma length product, exposure length product
Reference radiation quality	120 kV, HVL 8.4 mm Al (RQT9)
Design	not waterproof, vented, pencil type

Specification

Nominal sensitive volume	9.3 cm^3
Nominal response	13 nC/(Gy·cm)
Reference point	chamber center
Direction of incidence	radial
Chamber voltage	-100 V nominal ±500 V maximal high voltage to be connected only with active current-limiting device (Imax < 0.5 mA)
Energy response	≤ ±5 % for (50 ... 150) kV
Leakage current	≤ ±10 fA
Cable leakage	≤ 1 pC/(Gy·cm)

Materials and measures

Wall material	1 mm PMMA, graphite coated
Wall area density	119 mg/cm^2
Dimensions of sensitive	radius 3.5 mm volume length 300 mm
Electrode	Al tube, graphited outer diameter 3 mm

Ion collection efficiency at nominal voltage

Ion collection time	274 µs
Max. dose rate for ≥ 95.0 % saturation	12.4 Gy/s
Max. dose per pulse for ≥ 95.0 % saturation	2.2 mGy

Ranges of use

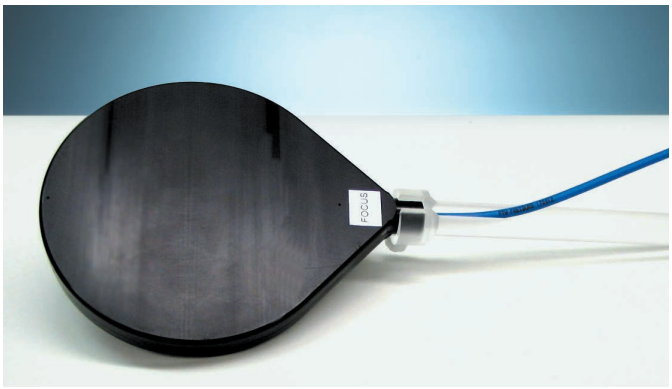
Chamber voltage	±(100 ... 400) V
Radiation quality	(50 ... 150) kV
Temperature	(10 ... 40) °C (50 ... 104) °F
Humidity	(10 ... 80) %, max 20 g/m^3
Air pressure	(700 ... 1060) hPa

Ordering Information

TN30017 CT chamber 9.3 cm^3, connecting system BNT
TW30017 CT chamber 9.3 cm^3, connecting system TNC
TM30017 CT chamber 9.3 cm^3, connecting system M
TL30017 CT chamber 9.3 cm^3, connecting system L

75 cm³ SFD Diagnostic Chamber Type 34060

Shadow-free plane-parallel chamber for absolute dosimetry in diagnostic radiology



- Shadow-free design for use with automatic exposure control / brightness control
- Sensitive volume 75 cm³, vented
- Suitable for measurements in front of and behind a phantom

The 34060 SFD diagnostic chamber is a general purpose, high precision chamber for measurements in diagnostic radiology. The chamber complies with the standard IEC 61674. Its shadow-free design makes it possible to use the chamber even while the automatic exposure control or brightness control is activated. Together with an adequate diagnostic dosemeter the chamber features a wide dynamic range for measurements either in front of or behind a patient-equivalent phantom. The length of the mounted connection cable is 2.5 m.

General

Type of product	vented plane-parallel ionization chamber acc. IEC 61674
Application	absolute dosimetry in diagnostic radiology
Measuring quantities	air kerma, exposure
Reference radiation quality	70 kV, HVL 2.58 mm Al (RQR5)
Design	not waterproof, vented
Direction of incidence	perpendicular to chamber plane, see label 'Focus'

Specification

Nominal sensitive volume	75 cm³
Nominal response	2.8 µC/Gy
Long-term stability	≤ 0.5 % per year
Chamber voltage	200 V nominal ±400 V maximal
Energy response	≤ ±2 % (50 ... 150) kV
Polarity effect	≤ 1 %
Reference point	chamber center
Directional response	≤ 3 % for chamber tilting up to ≤ ±15°
Leakage current	≤ ±5 fA
Cable leakage	≤ 1 pC/(Gy·cm)

Materials and measures

Entrance window	0.6 mm polycarbonate, 1.55 g/cm³ 0.002 mm graphite 0.32 g/cm³
Total window area density	93 mg/cm²
Water-equivalent window thickness	0.9 mm
Sensitive volume	radius 45.7 mm depth 2 x 5.71 mm

Ion collection efficiency at nominal voltage

Ion collection time	1 ms
Max. dose rate for ≥ 95 % saturation	0.78 Gy/s

Ranges of use

Chamber voltage	±(100 ... 400) V
Radiation quality	(25 ... 150) kV X-rays
Field size	(11 x 11) cm² ... (40 x 40) cm²
Temperature	(10 ... 40) °C (50 ... 104) °F
Humidity	(10 ... 80) %, max 20 g/m³
Air pressure	(700 ... 1060) hPa

Ordering Information

TN34060 SFD diagnostic chamber 75 cm³, connecting system BNT
TW34060 SFD diagnostic chamber 75 cm³, connecting system TNC
TM34060 SFD diagnostic chamber 75 cm³, connecting system M
TL34060 SFD diagnostic chamber 75 cm³, connecting system L

6 cm³ SFD Mammo Chamber Type 34069

Shadow-free plane-parallel chamber for absolute dosimetry in diagnostic radiology and mammography

- Shadow-free design for use with automatic exposure control
- Sensitive volume 6 cm³, vented
- Suitable for measurements in front of and behind a phantom

The 34069 SFD mammo chamber is a high precision chamber for measurements in diagnostic radiology at high dose rates and in mammography. The chamber complies with the standard IEC 61674. Its shadow-free design makes it possible to use the chamber even while the automatic exposure control is activated. Together with an adequate diagnostic dosemeter the chamber features a wide dynamic range for measurements either in front of or behind a patient-equivalent phantom. The length of the mounted connection cable is 2.5 m.

General

Type of product	vented plane-parallel ionization chamber acc. IEC 61674
Application	absolute dosimetry in diagnostic radiology
Measuring quantities	air kerma, exposure
Reference radiation quality	30 kV, HVL 0.337 mm Al (RQR-M3) 70 kV, HVL 2.58 mm Al (RQR5)
Design	not waterproof, vented
Direction of incidence	perpendicular to chamber plane, see label 'Focus'

Specification

Nominal sensitive volume	6 cm³
Nominal response	230 nC/Gy
Long-term stability	≤ 2 % per year
Chamber voltage	200 V nominal ±400 V maximal
Energy response	≤ ±2 % (25 ... 35) kV
Polarity effect	≤ 1 %
Reference point	chamber center
Directional response	≤ 3 % for chamber tilting up to ≤ ±15°
Leakage current	≤ ±5 fA
Cable leakage	≤ 1 pC/(Gy·cm)

Materials and measures

Entrance window	0.32 mm PMMA, 1.19 g/cm³ 0.002 mm graphite 0.32 g/cm³
Total window area density	38 mg/cm²
Water-equivalent window thickness	0.4 mm
Sensitive volume	radius 15.2 mm depth 2 x 4.21 mm

Ion collection efficiency at nominal voltage

Ion collection time	550 µs
Max. dose rate for ≥ 95 % saturation	2.65 Gy/s

Ranges of use

Chamber voltage	±(100 ... 400) V
Radiation quality	(25 ... 150) kV X-rays
Field size	(5 x 5) cm² ... (40 x 40) cm²
Temperature	(10 ... 40) °C (50 ... 104) °F
Humidity	(10 ... 80) %, max 20 g/m³
Air pressure	(700 ... 1060) hPa

Ordering Information

TN34069 SFD mammo chamber 6 cm³, connecting system BNT
TW34069 SFD mammo chamber 6 cm³, connecting system TNC
TM34069 SFD mammo chamber 6 cm³, connecting system M
TL34069 SFD mammo chamber 6 cm³, connecting system L

System Incorporated Detectors for Diagnostic Radiology

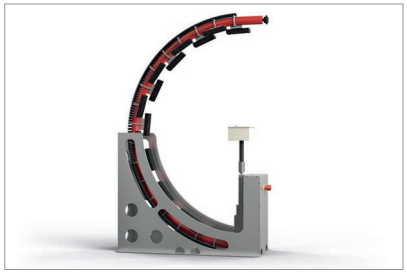
Besides the radiation detectors presented in this chapter, there are available a number of further detectors which are incorporated components of diagnostic dosemeters.

DIAMENTOR® Patient Dosimetry Chambers

DIAMENTOR chambers for dose area product measurements are available in different sizes and types to cover a wide range of diagnostic X-ray installations. The chambers can easily be mounted to the X-ray collimator or are firmly installed parts of the X-ray installation. The transparent models do not interfere with the collimators light field diaphragm.

NOMEX® Multimeter

The NOMEX Multimeter is a miniaturized non-invasive measuring system for absolute dosimetry and quality control in X-ray diagnostic radiology. It can be used for radiography, fluoroscopy, dental, CT and mammography (Mo/Mo, Mo/Rh, W/Al, W/Rh, W/Ag, Rh/Rh) application.



XLS X-Ray Leakage Chamber

The rectangular plane-parallel XLS ionization chamber is used as part of the XLS X-ray leakage system for radiation leakage measurements of diagnostic X-ray installations. Up to 18 of these chambers can be arranged for radiation leakage detection around X-ray tubes.

Radiation Monitoring Detectors

- Radiation Monitoring Chamber 3 l 50
- Radiation Monitoring Chamber 50 l 51
- Spherical Chamber 1 l 52
- Spherical Chambers 10 l 53
- Spherical Chambers PS-10 and PS-50 54
- Spherical Chamber TK-30 55
- Cylinder Stem Chamber 30 cm^3 56
- $H_p(10)$ Secondary Standard Chamber 57
- Monitor Ionization Chambers 58
- X-ray Therapy Monitor Chamber 59
- Böhm Extrapolation Chamber 60

3 Liter Radiation Monitoring Chamber Type 34031

Cylindrical polyethylene ionization chamber for stationary radiation monitoring of gamma radiation

- Vented sensitive volume of 3 liters
- Suitable as radiation monitoring chamber
- Gamma energy range 80 keV to 1.3 MeV

The 3 liter chamber is used as a stationary surveillance device for environmental radiation monitoring. The chamber is designed to measure protection level dose rates. The chamber is guarded up to the sensitive volume. Since the sensitive volume is open to the surroundings, air density correction is required for precise measurement. The cylindrical chamber is made of graphite coated polyethylene with 4 mm wall thickness. The ion-collecting electrode is made of graphite coated, too. The external chamber diameter is 150 mm and the length is approx. 200 mm. For the transfer of the measuring signal and the polarizing voltage, the chamber is supplied with two coaxial connectors. The maximal chamber polarizing voltage is 1000 V. The chamber is supplied with an integrated adapter for positioning a radioactive check source of type T48010, which makes it possible to check the proper performance of the entire measuring system.

General

Type of product	vented cylindrical ionization chamber
Application	radiation monitoring
Measuring quantities	photon equivalent dose
Design	not waterproof, vented

Specification

Nominal sensitive volume	3 l
Reference point	chamber center
Nominal response	100 µC/Sv
Chamber voltage	1000 V nominal
Energy response	≤ ±10 % (E_{photon} ≥ 80 keV)
Direction of incidence	radial
Directional response	≤ ±10 % for tilting
in air	perpendicular to the axis
	up to ±20°
Leakage current	≤ ±50 fA

Materials and measures

Wall of sensitive volume	4 mm PE graphite coated, 0.95 g/cm³
Total wall area density	0.38 g/cm²
Dimension of sensitive volume	radius 71.25 mm length 200 mm
Central electrode	graphite coated PE, diameter 28 mm
Outer dimensions	diameter 150 mm length 200 mm

Ion collection efficiency at nominal voltage

Ion collection time	27 ms
Max. dose rate for	
≥ 99 % saturation	0.95 Sv/h
≥ 90 % saturation	9.5 Sv/h

Ranges of use

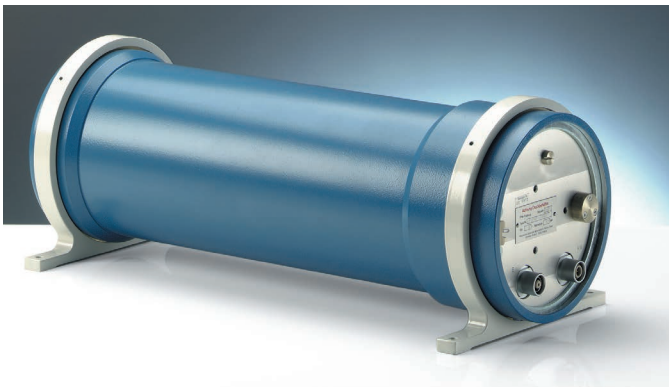
Chamber voltage	(400 ... 1000) V
Radiation quality	80 keV ... 1.3 MeV
Temperature	(10 ... 40) °C (50 ... 104) °F
Humidity	(10 ... 80) %, max 20 g/m³
Air pressure	(700 ... 1060) hPa

Ordering Information

T34031 Radiation monitoring chamber 3 l, Fischer coax connectors

T7262/U10-1,5 Connection cable with M connector, length 1.5 m

50 Liter Radiation Monitoring Chamber Type 7262



Cylindrical pressurized steel ionization chamber for stationary gamma radiation monitoring

- Sealed sensitive volume of 50 liters
- Suitable as stationary radiation monitoring chamber
- Gamma energy range 80 keV to 1.3 MeV

The ionization chamber T7262 has a constructive volume of 5 liters filled with Argon gas at the pressure of 10 bar, resulting in an effective sensitive volume of 50 liters. This superior design makes the chamber very sensitive and enables performing low level gamma radiation measurements down to the natural radiation background. The chamber is used as highly sensitive stationary surveillance device for environmental radiation monitoring. The chamber is guarded up to the sensitive volume. Since the sensitive volume is sealed, no air density correction is required. The cylindrical 50 liter chamber is made of steel with 3.25 mm wall thickness and a 3 mm aluminum cover. The ion-collecting electrode is made of brass. The external chamber diameter is 195 mm and the length is 538 mm. The chamber is supplied with two coaxial Fischer connectors for the transfer of the measuring signal and the polarizing voltage. Via an optional adapter cable of 1.5 m length, the chamber can be connected to a dosemeter with M connector, which has input circuits on ground potential. The maximal chamber polarizing voltage is 1000 V.

General

Type of product	pressurized cylindrical ionization chamber
Application	radiation monitoring
Measuring quantities	photon equivalent dose
Design	sealed and pressurized, filled with Ar (10 bar)

Specification

Nominal sensitive volume	50 l
Reference point	chamber center
Nominal response	2 mC/Sv
Chamber voltage	1000 V nominal
Energy response	≤ ±10 % (E_{photon} ≥ 80 keV)
Direction of incidence	radial
Directional response in air	≤ ±10 % for tilting perpendicular to the axis up to ±20°
Leakage current	≤ ±50 fA

Materials and measures

Wall of sensitive volume	3 mm Al, 2.7 g/cm³, 3.25 mm steel, 7.85 g/cm³
Total wall area density	3.361 g/cm²
Dimension of sensitive volume	radius 66.75 mm length 360mm
Central electrode	brass, diameter 17.5 mm
Outer dimensions	diameter 195 mm length 538 mm

Ion collection efficiency at nominal voltage

Ion collection time	30 ms
Max. dose rate for	
≥ 99 % saturation	1 mSv/h
≥ 90 % saturation	10 mSv/h

Ranges of use

Chamber voltage	(400 ... 1000) V
Radiation quality	80 keV ... 1.3 MeV
Temperature	(10 ... 40) °C (50 ... 104) °F
Humidity	(10 ... 80) %, max 20 g/m³
Air pressure	(700 ... 1060) hPa

Ordering Information

T7262 Radiation monitoring chamber 50 l,
Fischer coax connectors

Options

T7262/U10-1,5 Connection cable with M connector, length 1.5 m

1 Liter Spherical Ionization Chamber Type 32002

Spherical ionization chamber for radiation protection measurement

- Vented sensitive volume of 1 liter
- Suitable for survey meter calibration and low level measurements
- Superior energy response, reproducibility, directional dependence and long-term stability

The spherical chamber is designed for the measurement of ionizing radiation in radiation protection. Superior features make the chamber suitable as standard chamber for calibration purposes. It fulfills the requirement for excellent reproducibility and long-term stability of the sensitive volume. The spherical construction ensures a nearly uniform response to radiation from every direction. The energy response is very flat. This is achieved by the thin layer of aluminum on the inner wall surface, which provides for an increased photoelectric yield to compensate for the absorption of soft X-rays. The outer chamber diameter is 140 mm.

General

Type of product	vented spherical ionization chamber
Application	radiation protection measurement
Measuring quantities	air kerma, photon equivalent dose
Design	not waterproof, vented

Specification

Nominal sensitive volume	1 l
Reference point	chamber center
Nominal response	40 µC/Gy
Chamber voltage	400 V nominal, ±500 V maximal
Energy response	≤ ±4 %
Leakage current	≤ ±10 fA

Materials and measures

Wall of sensitive volume	3 mm POM (polyoxymethylene), 0.02 mm graphite 0.22 mm lacquer
Total wall area density	453 mg/cm^2
Central electrode	graphite coated polystyrene, diameter 50 mm
Outer dimensions	diameter 140 mm

Ion collection efficiency at nominal voltage

Ion collection time	37 ms
Max. dose rate for ≥ 90.0 % saturation	420 mGy/h
Max. dose per pulse for ≥ 99.0 % saturation	3.1 µGy

Ranges of use

Chamber voltage	±(300 ... 500) V
Radiation quality	25 keV ... 50 MeV
Temperature	(10 ... 40) °C (50 ... 104) °F
Humidity	(10 ... 80) %, max 20 g/m^3
Air pressure	(700 ... 1060) hPa

Ordering Information

TN32002 Spherical chamber 1 l, connection system BNT
TW32002 Spherical chamber 1 l, connection system TNC
TM32002 Spherical chamber 1 l, connection system M

Options

T48010 Radioactive check device ^{90}Sr
T48001 Chamber holding device for check device

10 Liter Spherical Ionization Chamber Type 32003

Spherical ionization chamber for radiation protection measurement

- Vented sensitive volume of 10 liters
- Suitable for survey meter calibration and low level measurements
- Superior energy response, reproducibility, directional dependence and long-term stability

The spherical chamber is designed for the measurement of ionizing radiation in radiation protection. Superior features make the chamber suitable as standard chamber for calibration purposes. It fulfills the requirement for excellent reproducibility and long-term stability of the sensitive volume. The spherical construction ensures a nearly uniform response to radiation from every direction. The energy response is very flat. This is achieved by the thin layer of aluminum on the inner wall surface, which provides for an increased photoelectric yield to compensate for the absorption of soft X-rays. The outer chamber diameter is 275 mm.

General

Type of product	vented spherical ionization chamber
Application	radiation protection measurement
Measuring quantities	air kerma, photon equivalent dose
Design	not waterproof, vented

Specification

Nominal sensitive volume	10 l
Reference point	chamber center
Nominal response	300 µC/Gy
Chamber voltage	400 V nominal, ±500 V maximal
Energy response	≤ ±3 %
Leakage current	≤ ±10 fA

Materials and measures

Wall of sensitive volume	2.75 mm POM (polyoxymethylene), 0.02 mm graphite 0.22 mm lacquer
Total wall area density	417 mg/cm^2
Central electrode	graphite coated polystyrene, diameter 100 mm
Outer dimensions	diameter 276 mm

Ion collection efficiency at nominal voltage

Ion collection time	150 ms
Max. dose rate for ≥ 90.0 % saturation	26 mGy/h
Max. dose per pulse for ≥ 99.0 % saturation	0.8 µGy

Ranges of use

Chamber voltage	±(300 ... 500) V
Radiation quality	25 keV ... 50 MeV
Temperature	(10 ... 40) °C (50 ... 104) °F
Humidity	(10 ... 80) %, max 20 g/m^3
Air pressure	(700 ... 1060) hPa

Ordering Information

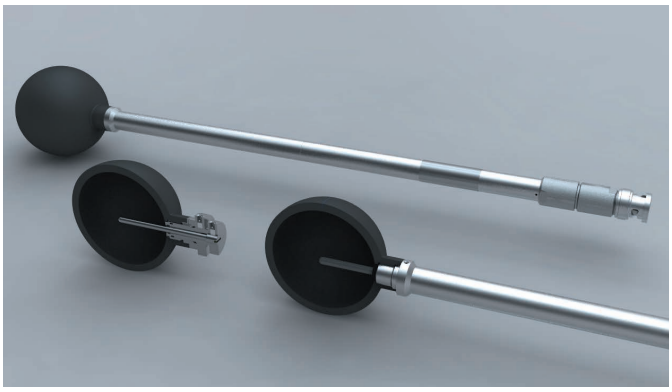
TN32003 Spherical chamber 10 l, connection system BNT
TW32003 Spherical chamber 10 l, connection system TNC
TM32003 Spherical chamber 10 l, connection system M

Options

T48010 Radioactive check device ^{90}Sr
T48001 Chamber holding device for check device

PS-50 and PS-10 Spherical Chambers Types 32007S, 32008OS

Primary standard spherical ionization chambers for radiation protection measurement



- Vented sensitive volume of 50 cm^3 and 10 cm^3
- Suitable as primary standard for radiation protection measurements
- Individual determination of exact volume
- Designed in collaboration with NIST (National Institute of Standards and Technology)

The spherical graphite chambers PS-50 and PS-10 are vented ionizing chambers for use as primary standard for radiation protection measurements and absolute dosimetry.
They have been designed in collaboration with the Radiation Interactions and Dosimetry Group at the National Institute of Standards and Technology (NIST). The exact volume of each chamber can be determined individually by the customer using a dummy stem. The homogeneity of the walls and electrodes is 0.06 mm. The chambers are constructed with a long rigid stem of approx. 29 cm length for easy mounting in the radiation beam. Air density correction is required for each measurement.

General

Type of product	vented spherical ionization chamber
Application	primary standard for radiation protection measurement
Measuring quantities	air kerma, photon equivalent dose
Design	not waterproof, vented

Specification

Nominal sensitive volume	50 cm^3 (32007S) 10 cm^3 (32008S)
Reference point	chamber center
Nominal response	1.73 µC/Gy (32007S) 0.349 µC/Gy (32008S)
Chamber voltage	1000 V nominal (32007S) 500 V nominal (32008S) ±1000 V maximal
Directional response in air	≤ ±0.5 % for rotation around the chamber axis and ≤ ±1 % for tilting the chamber axis up to ±60° (32007S), ≤ ±1 % for tilting of the chamber axis up to ±50° (32008S)
Leakage current	≤ ±5 fA

Materials and measures

Wall of sensitive volume	3.5 mm graphite
Total wall area density	647 mg/cm^2
Central electrode	graphite, diameter 3 mm
Outer dimensions	diameter 53 mm (32007S) diameter 34 mm (32008S)

Ion collection efficiency at nominal voltage

Ion collection time	8.7 ms (32007S) 1.9 ms (32008S)
Max. dose rate for	
≥ 99.5 % saturation	1.23 mGy/s (32007S) 26 mGy/s (32008S)
≥ 90.0 % saturation	2.46 mGy/s (32007S) 52 mGy/s (32008S)
Max. dose per pulse for	
≥ 99.5 % saturation	7.1 µGy (32007S) 33 µGy (32008S)
≥ 99.0 % saturation	14.2 µGy (32007S) 65 µGy (32008S)

Ranges of use

Chamber voltage	±(400 ... 1000) V
Radiation quality	^{60}Co, ^{137}Cs
Field size (square field)	≥ (6 x 6) cm^2 (32007S) ≥ (4 x 4) cm^2 (32008S)
Temperature	(10 ... 40) °C (50 ... 104) °F
Humidity	(10 ... 80) %, max 20 g/m^3
Air pressure	(700 ... 1060) hPa

Ordering Information

TN32007S Spherical chamber PS-50, connection system BNT
TN32007 Spherical chamber PS-50, incl. dummy stem, connection system BNT
TN32008S Spherical chamber PS-10, connection system BNT
TN32008 Spherical chamber PS-10, incl. dummy stem, connection system BNT

Spherical Ionization Chamber TK-30 Type 32005

Spherical ionization chamber with a long rigid stem for radiation protection measurement

- Vented sensitive volume of 28 cm^3
- Suitable as high precision reference chamber for radiation protection dosimetry
- Very flat energy response within a wide range

The spherical graphite chamber TK-30 has been designed as a reference chamber for absolute dosimetry to be used by secondary standard dosimetry laboratories (SSDL) and users with high quality requirements.
It has very small variations of response with radiation quality from low X-ray energies up to high-energy photon radiation.
The guard ring is designed up to the sensitive volume.
The chamber is constructed with a long rigid stem of approx. 20 cm length for easy mounting in the radiation beam.
Air density correction is required for each measurement..

General

Type of product	vented spherical ionization chamber
Application	radiation protection measurement
Measuring quantities	photon equivalent dose, exposure
Design	not waterproof, vented

Specification

Nominal sensitive volume	27.9 cm^3
Reference point	chamber center
Direction of incidence	radial
Nominal response	900 nC/Gy
Chamber voltage	400 V nominal, ±1000 V maximal
Energy response	≤ ±5 % (48 keV ... ^{60}Co)
Directional response in air	≤ ±0.5 % for rotation around the chamber axis and ≤ ±3 % for tilting of the chamber axis up to ±45°
Leakage current	≤ ±5 fA

Materials and measures

Wall of sensitive volume	3 mm POM (polyoxymethylene), 0.02 mm graphite 0.22 mm lacquer
Total wall area density	453 mg/cm^2
Dimension of sensitive volume	radius 22 mm
Central electrode	graphite coated PMMA, diameter 4.2 mm

Ion collection efficiency at nominal voltage

Ion collection time	4.5 ms
Max. dose rate for ≥ 99 % saturation	29.4 mGy/s
Max. dose per pulse for ≥ 99 % saturation	26 µGy

Ranges of use

Chamber voltage	±(200 ... 1000) V
Radiation quality	25 keV ... 50 MeV
Temperature	(10 ... 40) °C (50 ... 104) °F
Humidity	(10 ... 80) %, max 20 g/m^3
Air pressure	(700 ... 1060) hPa

Ordering Information

TN32005 Spherical chamber TK-30, connection system BNT
TW32005 Spherical chamber TK-30, connection system TNC
TM32005 Spherical chamber TK-30, connection system M

30 cm³ Cylinder Stem Ionization Chamber Type 23361

Cylindrical PMMA ionization chamber with a long rigid stem for radiation protection measurement

- Vented sensitive volume of 30 cm³
- Suitable as high precision reference chamber for radiation protection dosimetry
- Very flat energy response within a wide range

The cylindrical stem chamber has been designed as a reference chamber for absolute dosimetry to be used by secondary standard dosimetry laboratories (SSDL) and users with high quality requirements. It has very small variations of response with radiation quality from low X-ray energies up to high-energy photon radiation. The guard ring is designed up to the sensitive volume. The chamber is constructed with a long rigid stem of approx. 20 cm length for easy mounting in the radiation beam. An acrylic build-up cap with 3 mm wall thickness for in-air measurement in ^{60}Co beams is included with each chamber, as well as a calibration certifiate.
Air density correction is required for each measurement.
A radioactive check device with an appropriate holder is optionally available.

General

Type of product	vented cylindrical ionization chamber
Application	radiation protection measurement
Measuring quantities	air kerma, photon equivalent dose, exposure
Design	not waterproof, vented

Specification

Nominal sensitive volume	30 cm³
Reference point	on chamber axis, 27 mm from chamber tip
Direction of incidence	radial
Nominal response	1 µC/Gy
Chamber voltage	400 V nominal, ±500 V maximal
Energy response	≤ ±4 % (40 keV ... ^{60}Co)
Directional response in air	≤ ±0.5 % for rotation around the chamber axis, *for tilting see diagram page 70*
Leakage current	≤ ±10 fA
Stem leakage	≤ 1 pC/(Gy·cm)

Materials and measures

Wall of sensitive volume	1 mm PMMA, graphited
Total wall area density	119 mg/cm²
Dimension of sensitive volume	radius 15.5 mm, length 51 mm
Central electrode	graphite coated Al diameter 14 mm
Outer dimensions	diameter 33 mm length 335 mm
Build-up cap	PMMA, thickness 3 mm

Ion collection efficiency at nominal voltage

Ion collection time	1.3 ms
Max. dose rate for	
≥ 99.5 % saturation	60 mGy/s
≥ 90.0 % saturation	120 mGy/s
Max. dose per pulse for	
≥ 99.5 % saturation	50 µGy
≥ 99.0 % saturation	100 µGy

Ranges of use

Radiation quality	30 keV ... 50 MeV
Temperature	(10 ... 40) °C (50 ... 104) °F
Humidity	(10 ... 80) %, max 20 g/m³
Air pressure	(700 ... 1060) hPa

Ordering Information

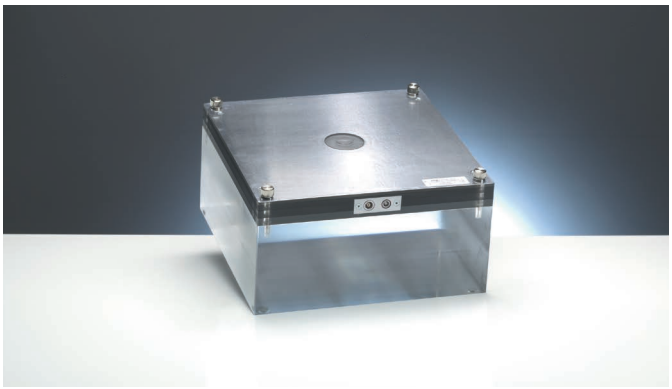
TN23361 Cylindrical stem chamber 30 cm³, connection system BNT
TW23361 Cylindrical stem chamber 30 cm³, connection system TNC
TM23361 Cylindrical stem chamber 30 cm³, connection system M

Options

T48010 Radioactive check device ^{90}Sr
T23237 Chamber holding device for check device

$H_p(10)$ Secondary Standard Chamber Type 34035

Plane-parallel ionization chamber for direct measurement of $H_p(10)$ personal dose equivalent on a slab phantom



- Vented sensitive volume of 10 cm^3
- Measures the $H_p(10)$ personal dose equivalent directly
- Suitable as a reference chamber for $H_p(10)$ calibration

The parallel plate ionization chamber model 34035[1] is integrated into a slab phantom to measure the $H_p(10)$ radiation protection measuring quantity directly. The high performance chamber is designed to be used as a secondary standard chamber for calibration purposes. The beam calibration with the $H_p(10)$ chamber makes it unnecessary to precisely determine the spectrum of the X-ray beam. The chamber comes uncalibrated: a primary standard calibration by PTB, the German National Laboratory, is available. The chamber set includes a phantom slab of 31 mm thickness with chamber assembly and an additional PMMA phantom slab of 120 mm thickness. Both sets available include an adapter cable to connect the chamber either to a dosemeter with M connector or with BNC connector and banana pin. The $H_p(10)$ chamber should be used in connection with a high quality dosemeter such as UNIDOS, UNIDOS E or UNIDOS^{webline} to ensure best performance.

General

Type of product	vented plane-parallel chamber
Application	radiation protection measurement
Measuring quantities	$H_p(10)$ personal dose equivalent
Design	not waterproof, vented

Specification

Nominal sensitive volume	10 cm^3
Reference conditions	20 °C, 1013 hPa 65 % rel. humidity
Reference point	chamber center, 13.5 mm below chamber surface or 15.5 mm below surface of integrated step cylinder
Nominal response	285 nC/Sv
Chamber voltage	400 V nominal
Leakage current	≤ ±10 fA
Cable leakage	≤ 1 pC/(Gy·cm)

Materials and measures

Phantom material	PMMA
Outer dimensions	300 mm x 300 mm
chamber assembly	height 31 mm
additional slab phantom	height 120 mm

Ranges of use

Chamber voltage	±(300 ... 500) V
Radiation quality	(15 ... 1400) keV
Temperature	(10 ... 40) °C
	(50 ... 104) °F
Humidity	(10 ... 80) %, max 20 g/m^3
Air pressure	(700 ... 1060) hPa

Ordering Information

L981937 $H_p(10)$ Secondary standard chamber type 34035, connecting system M

L981938 $H_p(10)$ Secondary standard chamber type 34035, connecting system BNC and banana pin

Option

PTB Primary standard calibration upon request

[1] Ankerhold, Ambrosi, Eberle - A chamber for determining the conventionally true value of $H_p(10)$ and $H^*(10)$ needed by calibration laboratories - Rad. Prot. Dos. Vol. 96, Nos 1-3, pp. 133 - 137 (2001), Nucl. Techn. Publishing

Monitor Ionization Chambers Type 34014, 786

Large size plane-parallel transmission chambers for use as dose monitors combined with calibration facilities

- Vented sensitive volume of 94 cm^3 and 86 cm^3
- Include twin-sensitive volumes
- Shadow-free transmission chambers for dose monitoring with calibration facilities

The circular plane-parallel transmission chambers are used for dose monitoring in combination with calibration benches. The sensitive volumes are designed as twin-chambers with 2.5 mm measuring depth each and a diameter of 155 mm (model 786) or 148 mm (model 34014). The chamber walls and the electrodes are made of polyimide (PI) of 0.025 mm thickness each with graphite layer. The chambers are guarded. The external diameter of the chamber housing is 230 mm. Two holes with 6 mm threads serve for mechanical chamber fixation.

Two chamber versions are available: model 786 is used together with dosemeters having the input circuits on ground potential, and model 34014 is used together with dosemeters having the input circuits on high voltage.

General

Type of product	vented plane-parallel twin-chambers
Application	dose monitoring in calibration facilities
Measuring quantities	exposure
Design	not waterproof, vented

Specification

Nominal sensitive volume	86 cm^3 (34014) 94 cm^3 (786)
Nominal response	depends on field size
Chamber voltage	400 V nominal
Energy response	≤ ±4 % (40 keV ... ^{60}Co)
Leakage current	≤ ±1 pA

Materials and measures

Entrance window	3 x 0.025 mm polyimide, graphite coated
Total window area density	3 x 3.55 mg/cm^2
Electrode	polyimide foil, graphite coated
Outer dimensions	diameter 230 mm

Ion collection efficiency at nominal voltage

Max. dose rate for	
≥ 99.5 % saturation	8.5 Gy/s
≥ 99.0 % saturation	17 Gy/s (34014) 18 Gy/s (786)
Max. dose per pulse for	
≥ 99.5 % saturation	590 µGy
≥ 99.0 % saturation	1.19 µGy

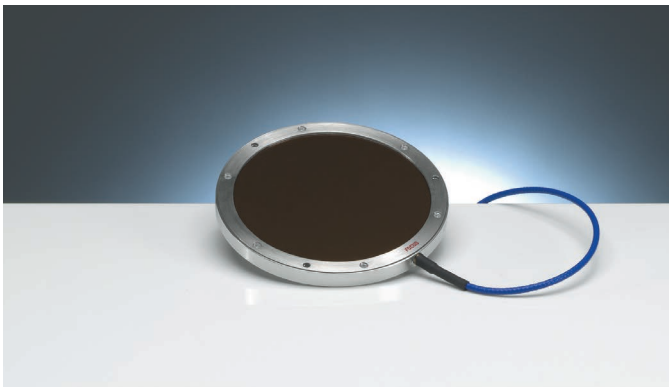
Ranges of use

Radiation quality	(7.5 ... 420) kV X-rays
Field size	≤ 148 mm diameter (34014) ≤ 155 mm diameter (786)
Temperature	(10 ... 40) °C (50 ... 104) °F
Humidity	(10 ... 80) %, max 20 g/m^3
Air pressure	(700 ... 1060) hPa

Ordering Information

TN34014 Monitor chamber, connecting system BNT
TW34014 Monitor chamber, connection system TNC
TM786 Monitor chamber, connection system M
TB786 Monitor chamber, connection system BNC and banana pin

X-ray Therapy Monitor Chamber Type 7862



Large size plane-parallel transmission chamber for use as dose monitor combined with X-ray therapy units

- Vented sensitive volume of 17.6 cm^3
- Shadow-free transmission chamber for dose monitoring with radiation therapy X-ray equipment

The circular plane-parallel transmission chamber model 7862 is used for dose monitoring in combination with radiotherapy X-ray units. The sensitive volume is designed as a very thin cylinder of 2.4 mm thickness and 96.5 mm diameter. The chamber wall and the electrode are made of polyimide (Pl) of 0.05 mm thickness each with graphite layer, mechanically protected by another Pl foil of 00.05 mm in front of each wall. The nominal photon energy range is 7.5 kV up to 420 kV and the leakage current is less than 1 pA. The chamber housing is 119.5 mm. Three holes with 3.5 mm threads serve for mechanical chamber fixation. The transmission chamber model 7862 is used in connection with dosemeters having th input circuits on ground potential.

General

Type of product	vented plane-parallel triple-chambers
Application	dose monitoring in X-ray therapy units
Measuring quantities	exposure
Design	not waterproof, vented

Specification

Nominal sensitive volume	17.6 cm^3
Nominal response	depends on field size
Chamber voltage	400 V nominal
Energy response	≤ ±4 % (40 keV ... ^{60}Co)
Leakage current	≤ ±1 pA

Materials and measures

Entrance window	4 x 0.05 mm polyimide, graphite coated
Total window area density	4 x 7.1 mg/cm^2
Electrode	polyimide foil, graphite coated
Outer dimensions	diameter 119.5 mm

Ion collection efficiency at nominal voltage

Max. dose rate for	
≥ 99.5 % saturation	10 Gy/s
≥ 99.0 % saturation	20 Gy/s
Max. dose per pulse for	
≥ 99.5 % saturation	640 µGy
≥ 99.0 % saturation	1.29 µGy

Ranges of use

Radiation quality	(7.5 ... 420) kV X-rays
Field size	≤ 95 mm diameter
Temperature	(10 ... 40) °C (50 ... 104) °F
Humidity	(10 ... 80) %, max 20 g/m^3
Air pressure	(700 ... 1060) hPa

Ordering Information

TM7862 Monitor chamber for X-ray therapy units, connecting system M

Böhm Extrapolation Chamber Type 23392

Low energy extrapolation chamber with adjustable volume depth for measurements of absorbed dose in soft tissue

- Measures absolute dose of beta radiation and X-rays in soft tissue equivalent material very precisely
- Includes a micrometer screw for the depth
- Very Suitable for beta calibration at PSDLs and SSDLs

The Böhm extrapolation chamber is a high quality device for absorbed dose measurements of beta and low energy X radiation in certain depths below the surface of the entrance window. Primary standard dosimetry laboratories (PSDL) use it for low energy radiation calibration. The dose is determined from the ionization density in a small air gap, the extrapolation chamber volume, embedded in tissue equivalent material (PMMA). The chamber is supplied with a very thin entrance window of 0.75 mg//cm^2 and a collecting electrode of 30 mm in diameter. By means of the built-in micrometer screw, the collecting electrode surrounded by a guard ring of 15 mm can be moved to adjust the depth of the sensitive volume between 10.5 mm and 0.5 mm. The zero point of the chamber depth setting can be obtained by measuring the chamber capaciting charge C versus the chamber depth x and extrapolating C^{-1} towards x = 0. The chamber is equipped with two BNC sockets for signal and polarizing voltage. A connection cable from both BNC sockets to an electrometer with M type connector is available. An electrometer with the input circuits on ground potential is required. The extrapolation chamber comes in a protective storage case.

General

Type of product	extrapolation chamber according to Böhm
Application	absolute dosimetry of beta radiation and X-rays
Measuring quantities	absorbed dose in soft tissue
Design	not waterproof, vented, guarded

Specification

Nominal sensitive volume	(0.353 ... 7.422) cm^3
Reference point	inner surface of the entrance window, at the center of the window
Direction of incidence	radial
Nominal response	dependent on electrode distance
Chamber voltage	dependent on electrode distance 500 V maximal
Leakage current	≤ ±1 pA
Cable leakage	≤ 1 pC/(Gy·cm)

Materials and measures

Entrance window	PET, graphite coated
Total window area density	0.75 mg/cm^2
Measuring electrode	diameter 30 mm
Rear electrode	PMMA, graphite coated diameter 60.5 mm
Distance between electrodes	(0.5 ... 10.5) mm

Ion collection efficiency at nominal voltage

Ion collection time max. dose rate	dependent on electrode distance

Ranges of use

Temperature	(10 ... 40) °C (50 ... 104) °F
Humidity	(10 ... 80) %, max 20 g/m^3
Air pressure	(700 ... 1060) hPa

Ordering Information

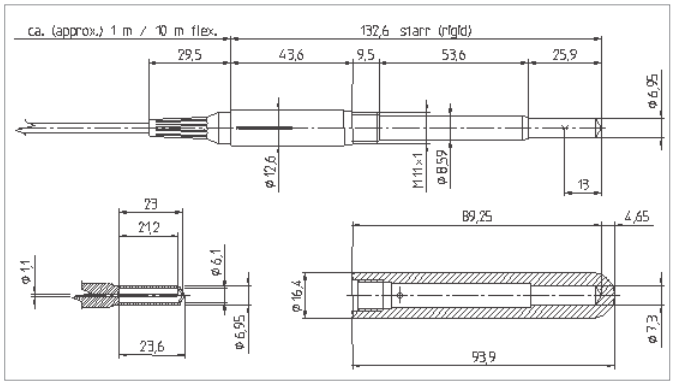
T23392 Böhm extrapolation chamber

T23392/U5 Connection cable for Böhm extrapolation chamber, connecting system M

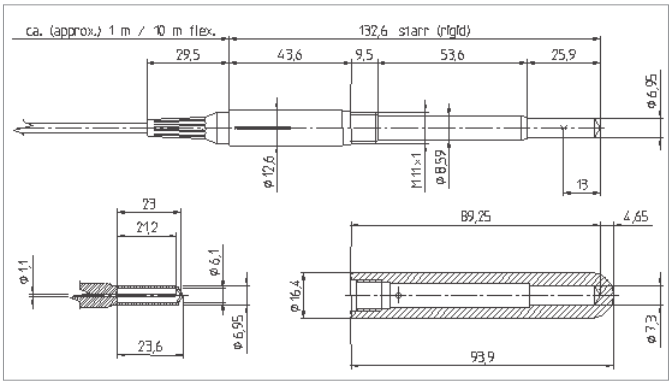
Quick View

- Drawings and Diagrams 62
- Connector Design 70
- Overview of PTW Detectors 72

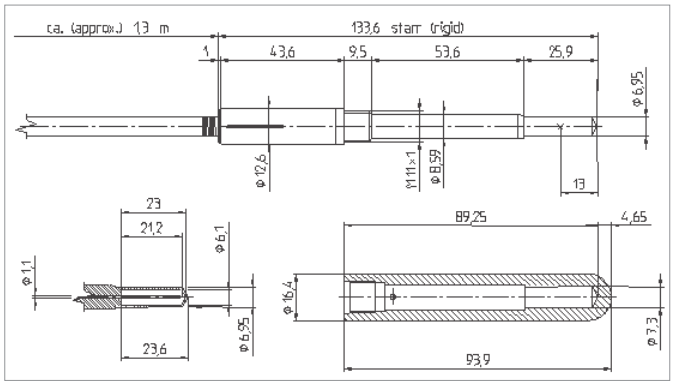
Drawings



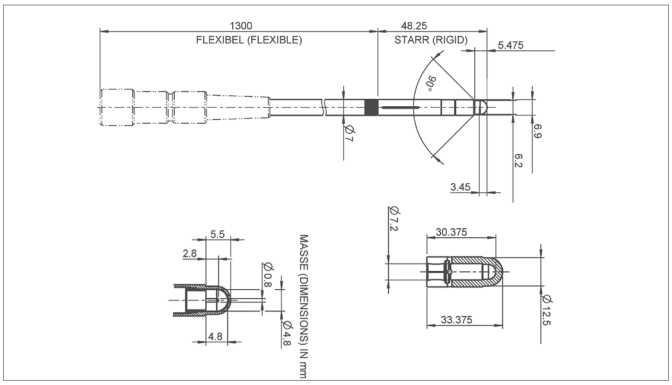
Farmer Chamber 30010



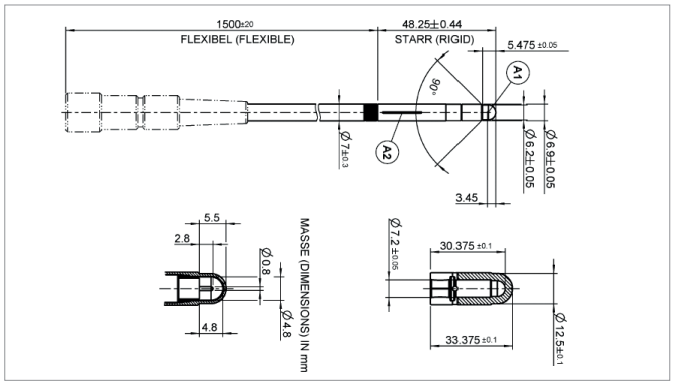
Farmer Chamber 30012



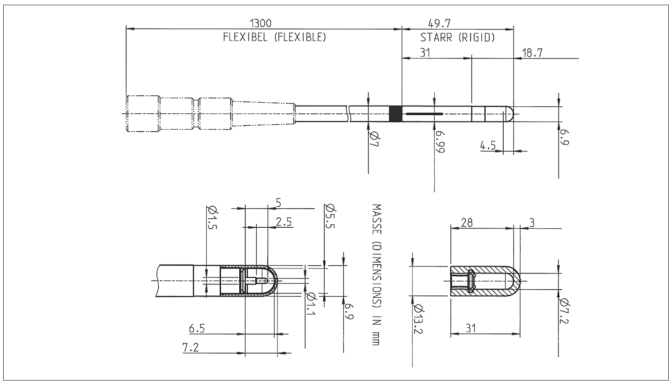
Farmer Chamber 30013



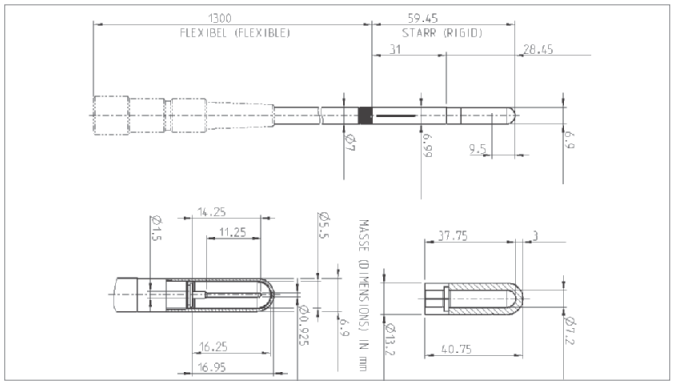
0.07 cm³ Semiflex 3D Chamber 31021



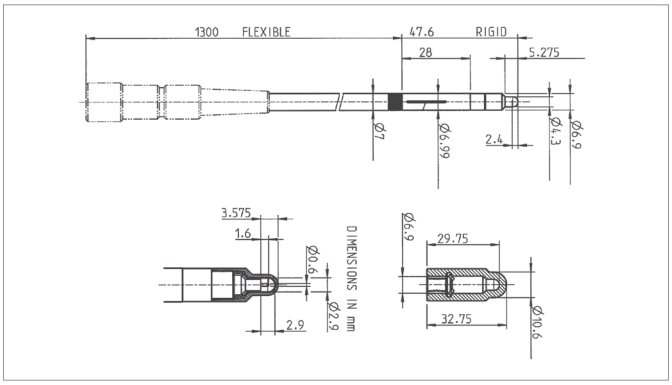
Semiflex 3D MR 31024



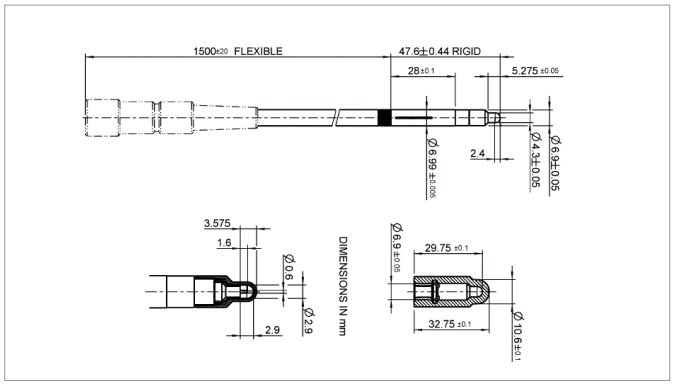
0.125 cm³ Semiflex Chamber 31010



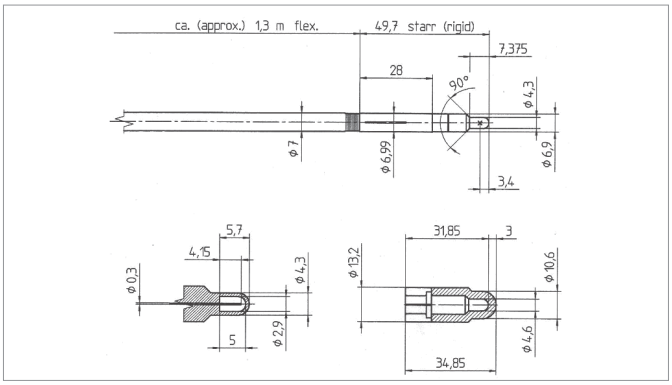
0.3 cm³ Semiflex Chamber 31013



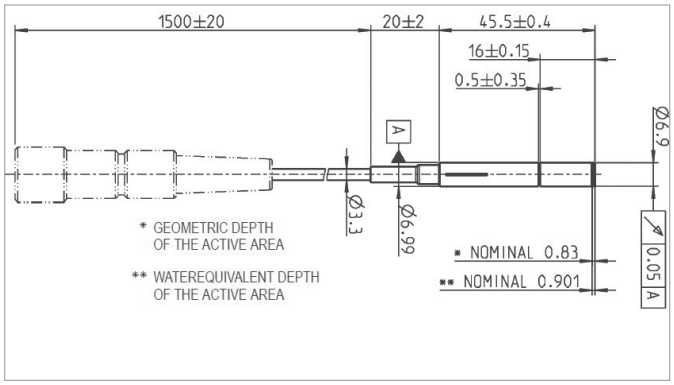
PinPoint 3D Chamber 31022



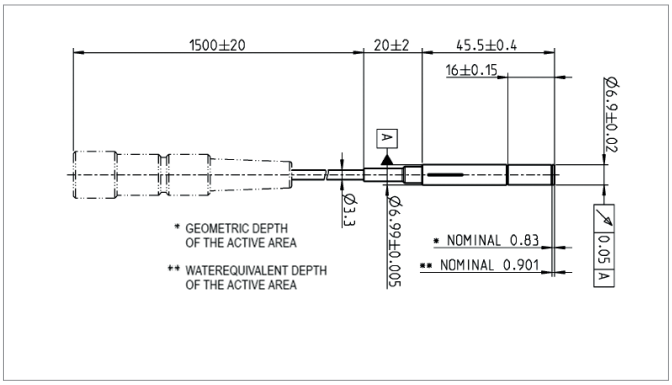
PinPoint 3D MR 31025



PinPoint Chamber 31015

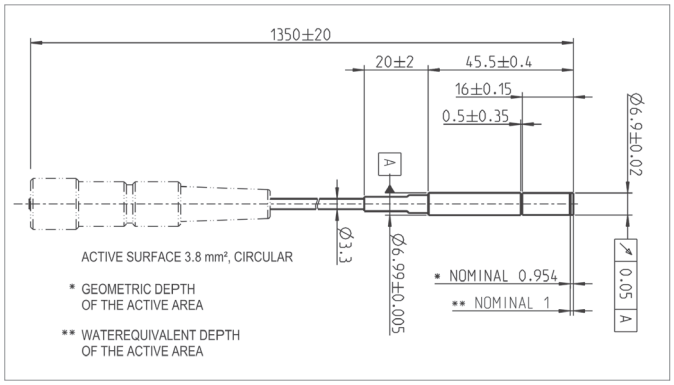


microSilicon 60023

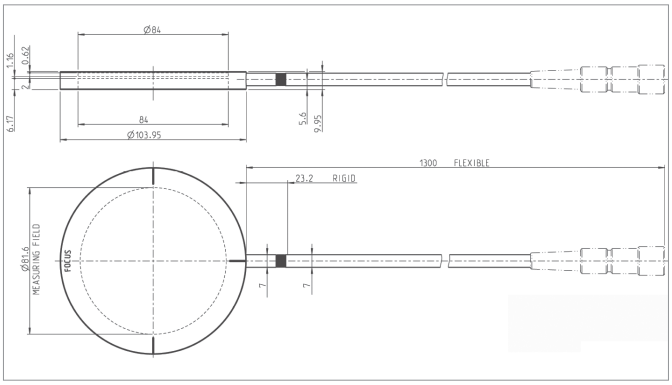


microSilicon X 60022

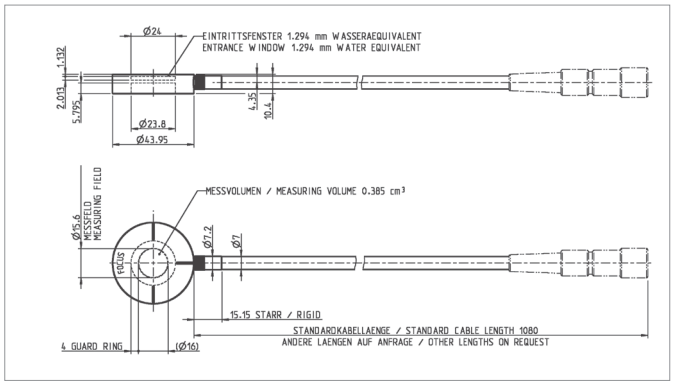
Drawings



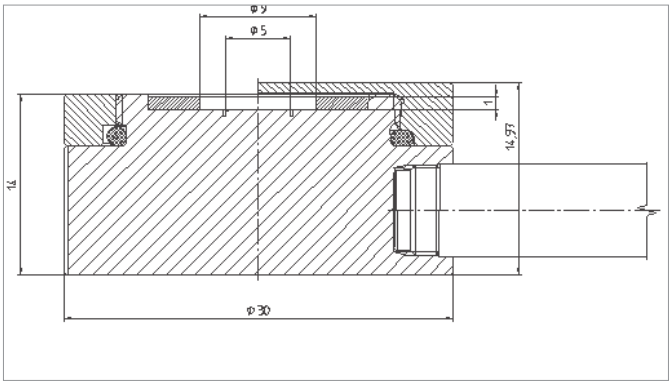
microDiamond 60019



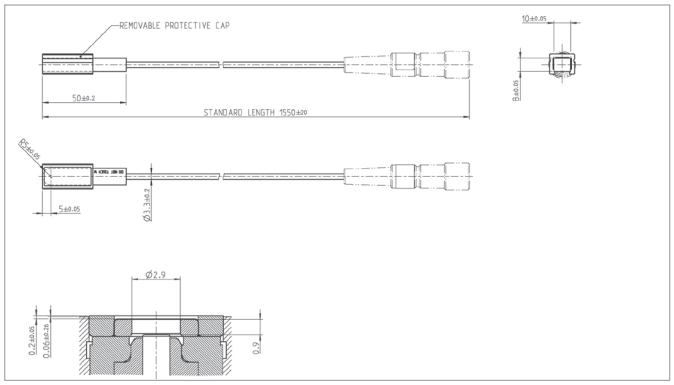
T-REF Chamber 34091



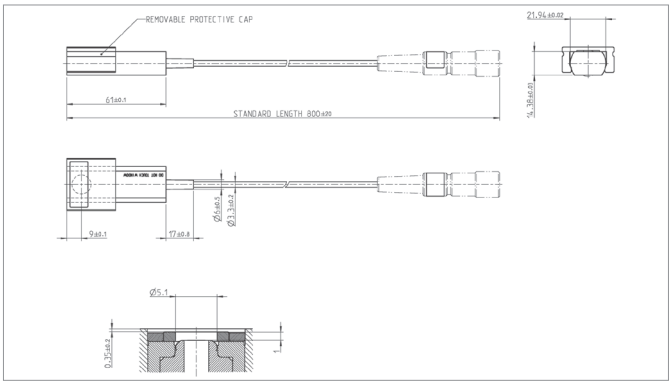
Roos Chamber 34001



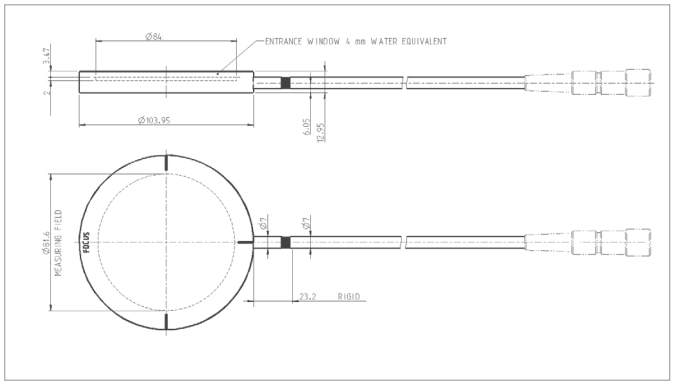
Advanced Markus Chamber 34045



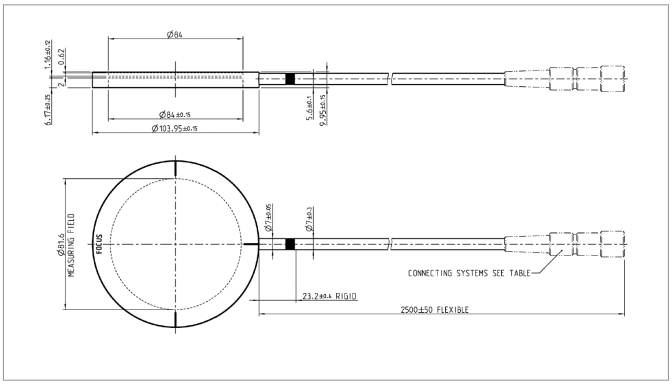
0.005 cm³ Soft X-Ray Chamber 34013



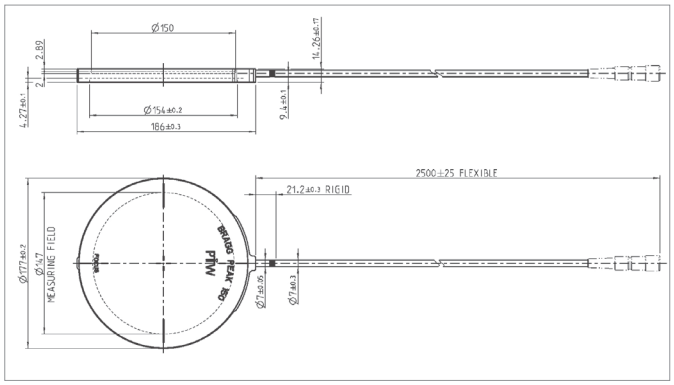
0.02 cm³ Soft X-Ray Chamber 23342



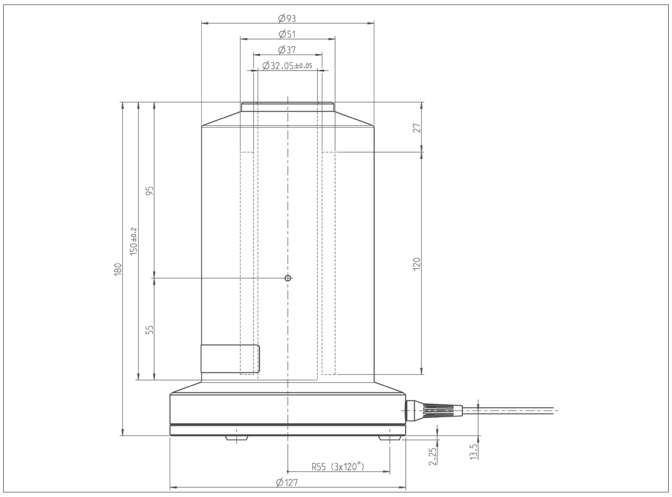
10.5 cm³ Bragg Peak Chamber 34070



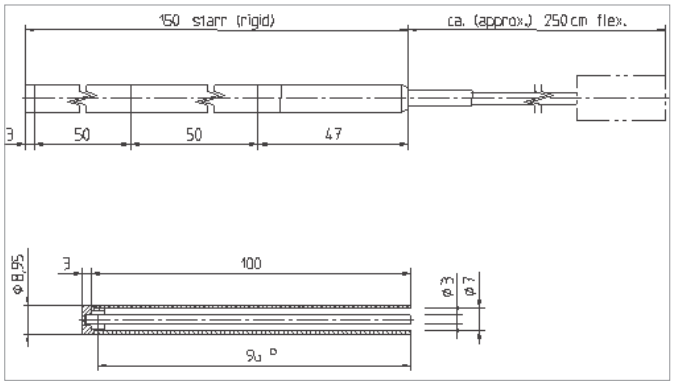
10.5 cm³ Bragg Peak Chamber 34080



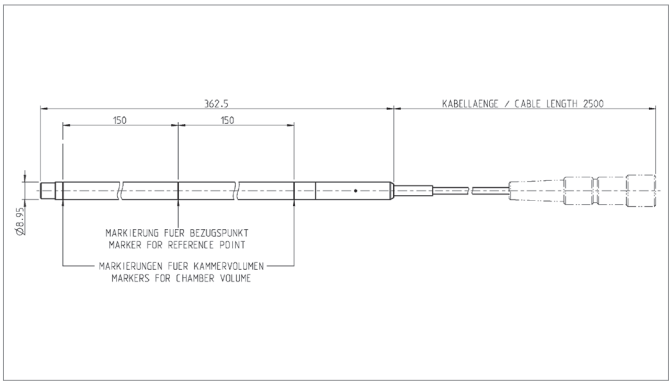
34 cm³ Bragg Peak 150 Chamber 34089



SOURCECHECK 4π 33005

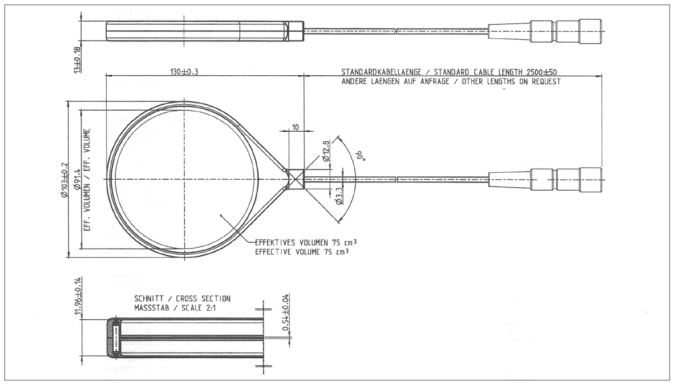


3.14 cm³ CT Chamber 30009

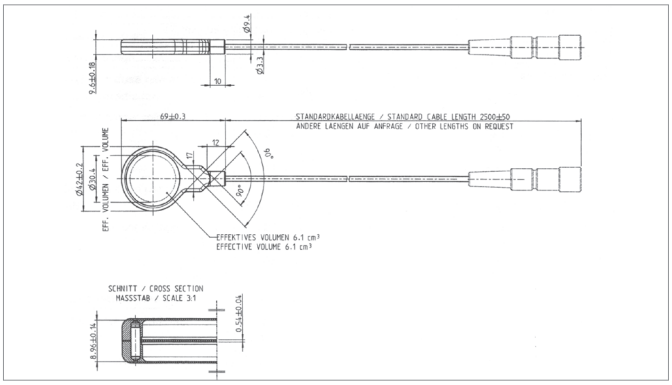


9.3 cm³ CT Chamber 30017

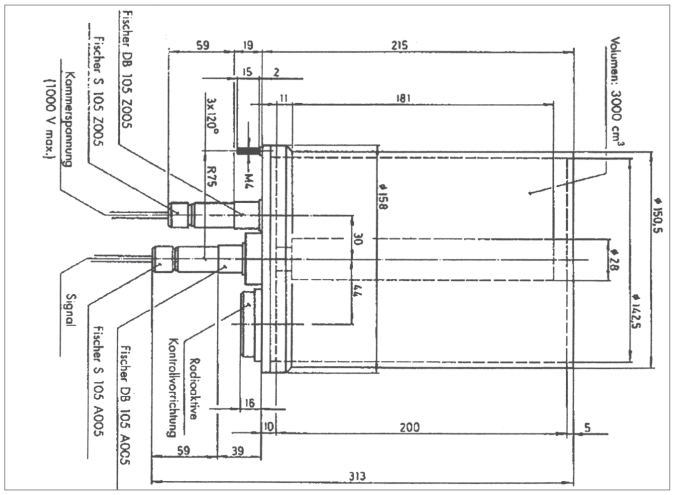
Drawings


STANDARDKABELLAENGE / STANDARD CABLE LENGTH 2500±50
ANDERE LAENGEN AUF ANFRAGE / OTHER LENGTHS ON REQUEST
EFFEKTIVES VOLUMEN 75 cm³
EFFECTIVE VOLUME 75 cm³
SCHNITT / CROSS SECTION
MASSSTAB / SCALE 2:1

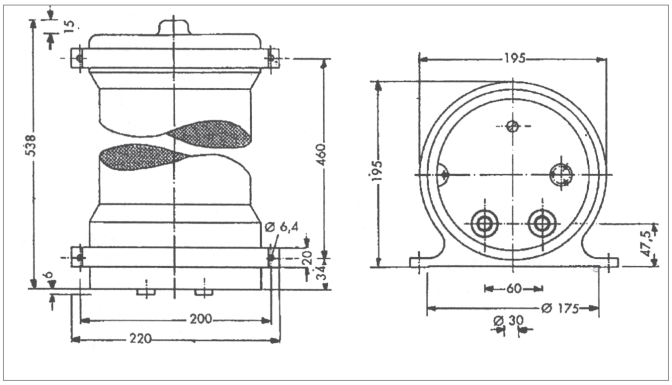
75 cm³ SFD Diagnostic Chamber 34060


STANDARDKABELLAENGE / STANDARD CABLE LENGTH 2500±50
ANDERE LAENGEN AUF ANFRAGE / OTHER LENGTHS ON REQUEST
EFFEKTIVES VOLUMEN 6.1 cm³
EFFECTIVE VOLUME 6.1 cm³
SCHNITT / CROSS SECTION
MASSSTAB / SCALE 3:1

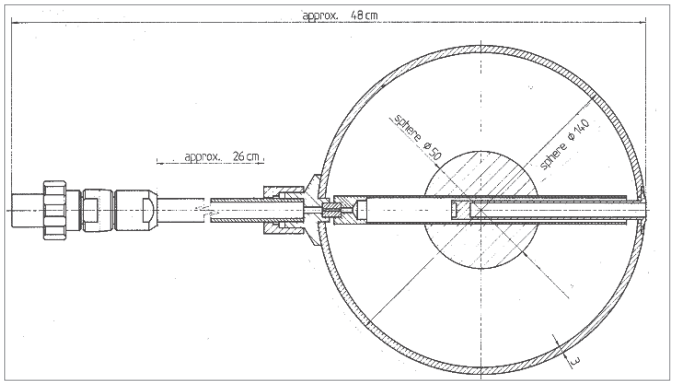
6 cm³ SFD Mammo Chamber 34069



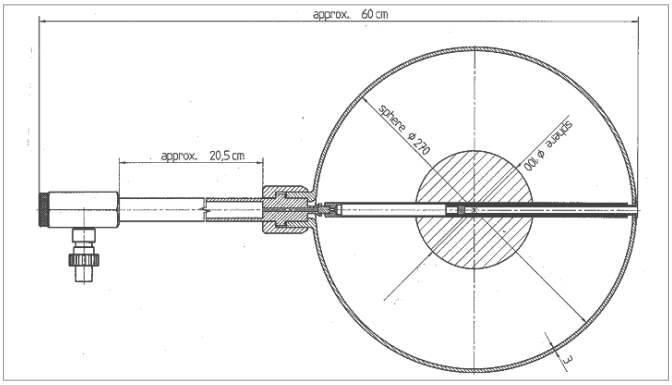
3 Liter Radiation Monitoring Chamber 34031



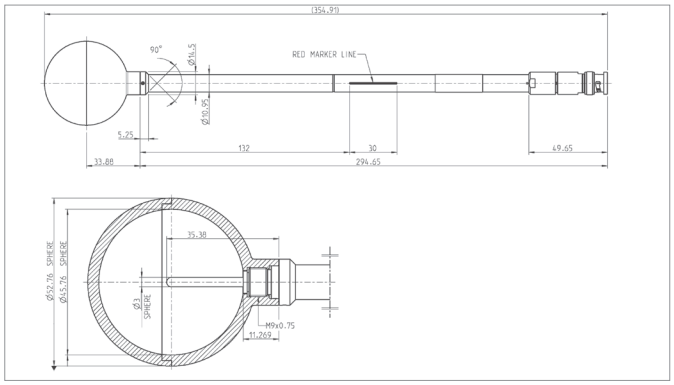
50 Liter Radiation Monitoring Chamber 7262



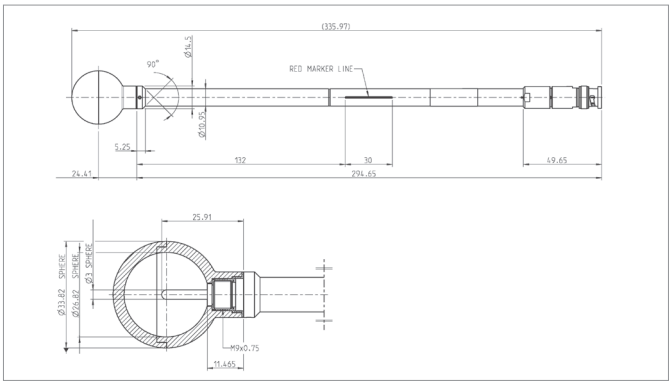
1 Liter Spherical Ionization Chamber 32002



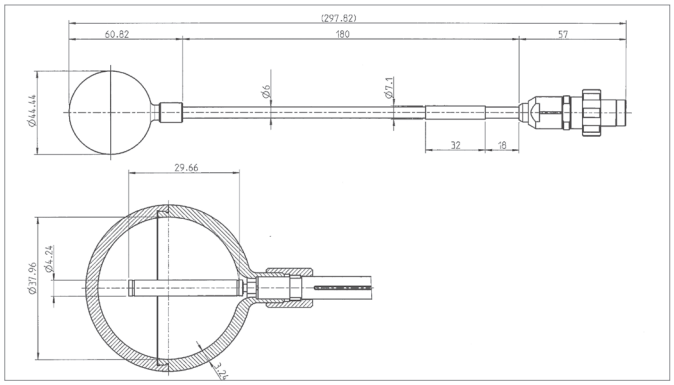
10 Liter Spherical Ionization Chamber 32003



50 cm³ Spherical Ionization Chamber PS-50 32007S

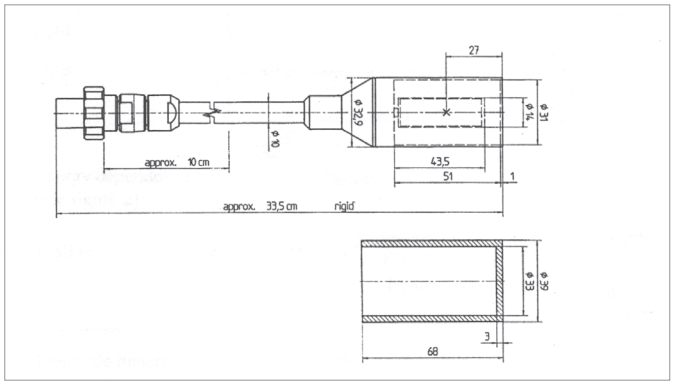


10 cm³ Spherical Ionization Chamber PS-10 32008S

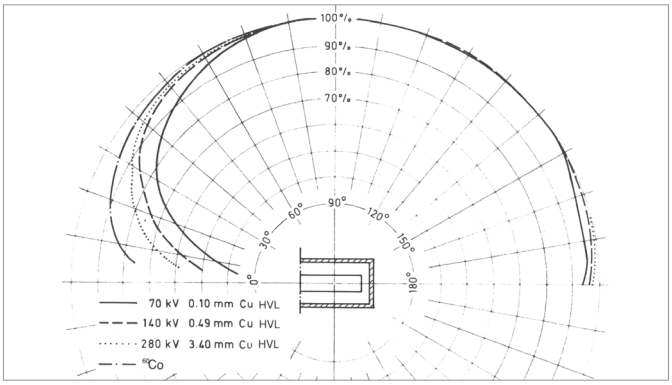


Spherical Ionization Chamber TK-30 32005

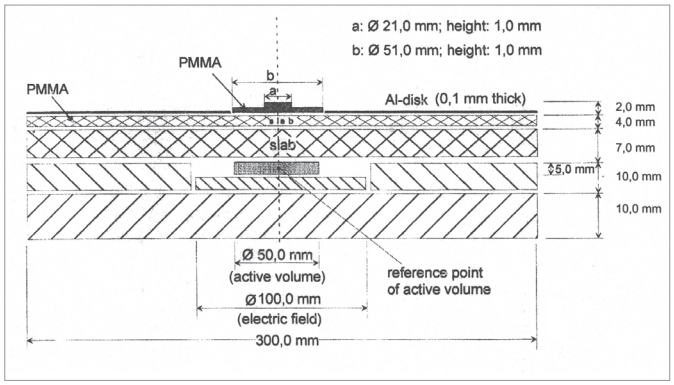
Drawings



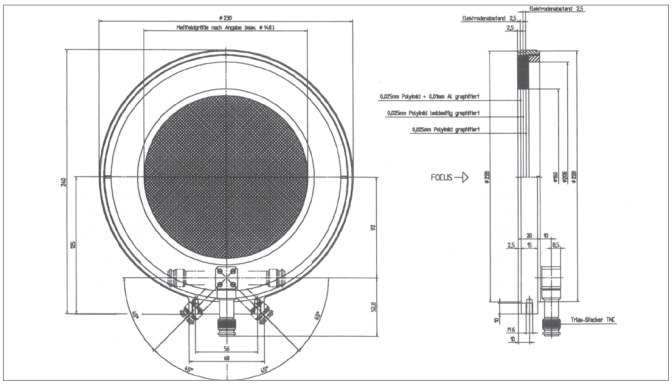
30 cm³ Cylinder Stem Ionization Chamber 23361



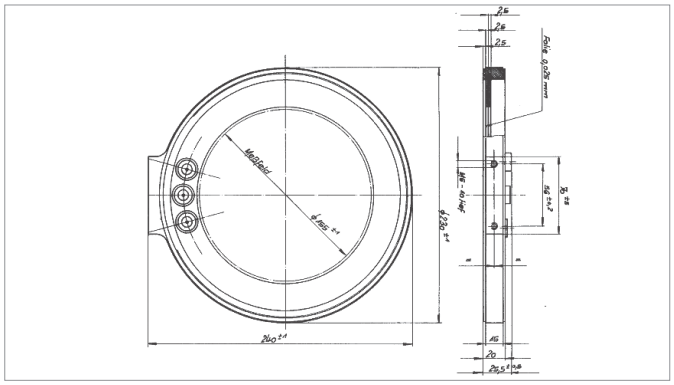
30 cm³ Cylinder Stem Ionization Chamber 23361
Directional response in air



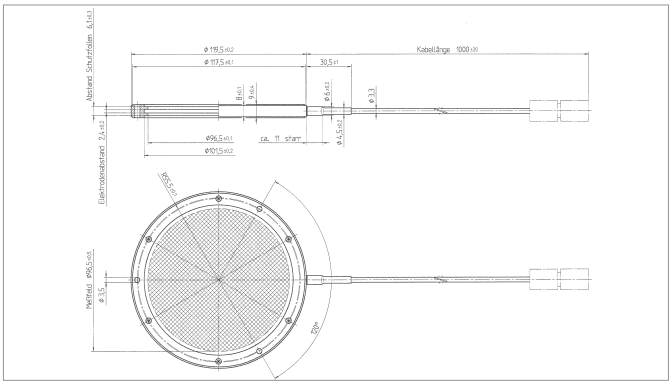
$H_p(10)$ Secondary Standard Chamber 34035



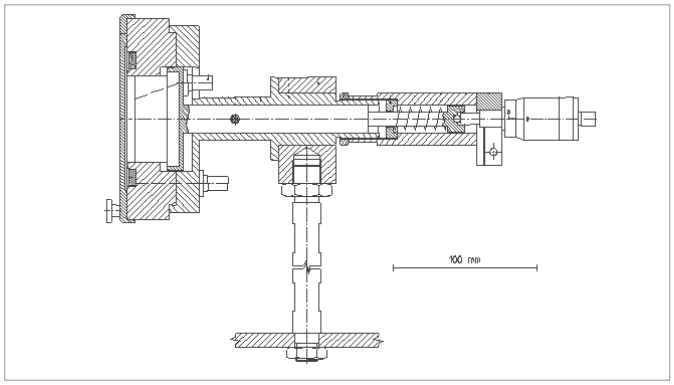
Monitor Ionization Chamber 34014



Monitor Ionization Chamber 786



X-Ray Therapy Monitor Chamber 7862



Böhm Extrapolation Chamber 23392

The Connector Design

The following overview of connecting systems facilitates the identifications of the adequate connector to fit your measuring system. Outer shape, colors and the size of the housing may vary, depending on the production year and the manufacturer. Some connectors may have protective covers which veil the real shape of the connector. All connectors are displayed without such protective covers. The images are not full-scale. See table below for approximate outer connector diameters.

BNT Connector (N type) male

BNT Connector (n type) female

TNC Connector (W type) male

TNC Connector (w type) female

Triax PTW Connector (M type) male

Triax PTW Connector (m type) female

BNC Connector with Banana Pin (B type) male

BNC Connector with Banana Pin (b type) female

Lemo Connector (L type) male

Lemo Connector (l type) female

DIAMENTOR Connector (V type) male

DIAMENTOR Connector (v type) female

DIAMENTOR Connector (A type) male

DIAMENTOR Connector (a type) female

DIAMENTOR Connector (F type) male

DIAMENTOR Connector (f type) female

As each manufacturer has its own manufacturing tolerances for connectors, PTW cannot guarantee that its TNC connectors fit to connectors supplied by other manufacturers.

The following table shows the possible connector combinations used in radiation therapy

	N, n	W, w	M, m	B, b
N, n	✓	✓	✗	✗
W, w	✓	✓	✗	✗
M, m	✗	✗	✓	✓
B, b	✗	✗	✓	✓

✓ Suitable adaption cable
✗ Unsuitable adaption cable

Approximate outer connector diameters

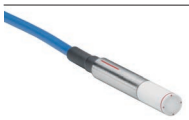
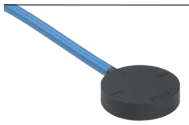
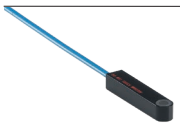
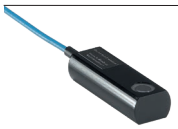
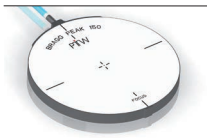
Connector Type	Outer Diameter
N, n	15 mm, 14 mm
W, w	16 mm, 14 mm
M, m	25 mm, 24 mm
B, b	18 mm, 18 mm
L, l	9 mm, 9 mm
V, v	15 mm, 16 mm
A, a	14 mm, 14 mm
F, f	18 mm, 19 mm

Guide to PTW Detectors

This guide gives a review of the complete range of PTW radiation detectors arranged in the order of their scope. Some of the detectors are suitable for various applications. Especially the ion chambers designed for reference dosimetry in radiotherapy can also be used for therapy beam analysis. All ionization chambers are supplied with vented sensitive volumes, except if stated otherwise. Radiation detectors which are integrated components of radiation measuring systems, such as array detectors (e.g. OCTAVIUS, STARCHECK) or DIAMENTOR, are not listed in this guide.

Radiation Therapy

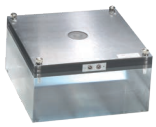
				page
	30013	0.6 cm³ Farmer Chamber waterproof	Waterproof chamber with acrylic wall and Al electrode for measuring high-energy photon and electron radiation in air, water and phantom material. BNT, TNC or M connector	20
	30010	0.6 cm³ Farmer Chamber PMMA/Al	Thimble chamber with acrylic wall and Al electrode for measuring high-energy photon and electron radiation in air and phantom material. BNT, TNC or M connector	21
	30012	0.6 cm³ Farmer Chamber Graphite/Al	Thimble chamber with graphite wall and Al electrode for measuring high-energy photon and electron radiation in air and phantom material. BNT or TNC connector	22
	31021	0.07 cm³ Semiflex 3D Chamber	Waterproof thimble chamber with 3D characteristics for measuring high-energy photon and electron radiation in air, water and phantom material. BNT, TNC or M connector	23
	31024	0.07 cm³ Semiflex 3D MR Chamber	Waterproof thimble chamber with 3D characteristics for measuring high-energy photon and electron radiation in air, water and phantom material in MR environments. TNC connector	24
	31010	0.125 cm³ Semiflex Chamber	Waterproof thimble chamber for measuring high-energy photon and electron radiation in air, water and phantom material. BNT, TNC or M connector	25
	31013	0.3 cm³ Semiflex Chamber	Waterproof thimble chamber for measuring high-energy photon and electron radiation in air, water and phantom material. BNT, TNC or M connector	26
	31022	0.016 cm³ PinPoint 3D Chamber	Ultra small-sized waterproof therapy chamber with 3D characteristics for dosimetry in high-energy photon beams. BNT, TNC or M connector	27
	31025	0.016 cm³ PinPoint 3D MR Chamber	Ultra small-sized waterproof therapy chamber with 3D characteristics for dosimetry in high-energy photon beams in MR environments. TNC connector	28
	31015	0.03 cm³ PinPoint Chamber	Small-sized waterproof therapy chamber for dosimetry in high-energy photon beams. BNT, TNC or M connector	29

				page
	60023	microSilicon for Electrons and Photons	Waterproof silicon diode detector for dosimetry in high-energy electron and photon beams. BNT, TNC or M connector	30
	60022	microSilicon X for Photons	Waterproof silicon diode detector for dosimetry in high-energy photon beams. BNT, TNC or M connector	31
	60019	microDiamond	Waterproof small volume diamond detector for dosimetry in high-energy photon beams. BNT, TNC or M connector	32
	34091	T-REF Chamber	Reference detector for small fields. BNT, TNC or M connector	33
	34001	0.35 cm^3 Roos Electron Chamber	Precision plane-parallel chamber for reference dosimetry of high-energy electron radiation in water and phantom material. BNT, TNC or M connector	34
	34045	0.02 cm^3 Advanced Markus Electron Chamber	Improved plane-parallel chamber with thin membrane for measuring high-energy electron radiation in water and phantom material. BNT, TNC or M connector	35
	34013	0.005 cm^3 Soft X-ray Chamber	Plane-parallel chamber with thin membrane for measuring small size therapeutic X-ray beams between 15 and 50 kV in air and phantom material. BNT, TNC or M connector	36
	23342	0.02 cm^3 Soft X-ray Chamber	Plane-parallel chamber with thin membrane for measuring therapeutic X-ray beams between 10 and 100 kV in air and phantom material. BNT, TNC or M connector	37
	34070	10.5 cm^3 Bragg Peak Chamber	Waterproof plane-parallel chamber for measuring the exact loacation of the Bragg peak in horizontal proton beams. BNT, TNC or M connector	38
	34080	10.5 cm^3 Bragg Peak Chamber	Waterproof plane-parallel chamber for measuring the exact loacation of the Bragg peak in horizontal proton beams. BNT, TNC or M connector	39
	34089	34 cm^3 Bragg Peak 150 Chamber	Very large waterproof plane-parallel chamber for measuring the exact loacation of the Bragg peak in horizontal proton beams. BNT, TNC or M connector	40
	33005	SOURCECHECK 4π Well-type Chamber	Well-type ionization chamber for source strength measurements in brachytherapy. BNT, TNC and M connector	41

Diagnostic Radiology

				page
	30009	3.14 cm³ CT Chamber	Vented cylindrical chamber for dose length product measurements in computed tomography. BNT, TNC, M or L connector	44
	30017	9.3 cm³ CT Chamber	Vented cylindrical chamber for dose length product measurements in computed tomography. BNT, TNC, M or L connector	45
	34060	75 cm³ SFD Diagnostic Chamber	Shadow-free plane-parallel chamber for absolute dosimetry in diagnostic radiology. M or L connector	46
	34069	6 cm³ SFD Mammo Chamber	Shadow-free plane-parallel chamber for absolute dosimetry in diagnostic radiology and mammography. BNT, TNC, M or L connector	47

Radiation Monitoring

				page
	34031	3 Liter Cylindrical Chamber	Cylindrical poly ethylene chamber for stationary low level gamma radiation measurement above 80 keV. Special connectors for signal and HV	50
	7262	50 Liter Cylindrical Chamber	Cylindrical pressurized steel chamber for stationary lowest level gamma radiation measurement above 80 keV. Special connectors for signal and HV	51
	32002	1 Liter Spherical Chamber	Spherical chamber, 140 mm diameter, for low level gamma radiation protection measurements in the energy range of 45 keV to 50 MeV. BNT, TNC or M connector	52
	32003	10 Liter Spherical Chamber	Spherical chamber, 270 mm diameter, for lowest level gamma radiation protection measurements in the energy range of 45 keV to 50 MeV. BNT, TNC or M connector	53
	32007S	50 cm^3 Spherical Chamber PS-50	Spherical chamber, 53 mm diameter, for primary standard radiation protection measurements in ^{60}Co and ^{137}Cs beams. BNT connector	54
	32008S	10 cm^3 Spherical Chamber PS-10	Spherical chamber, 34 mm diameter, for primary standard radiation protection measurements in ^{60}Co and ^{137}Cs beams. BNT connector	54
	32005	30 cm^3 Spherical Chamber	Spherical chamber, 22 mm diameter, for gamma radiation protection measurements in the energy range of 30 keV to 50 MeV. BNT, TNC or M connector	55
	23361	30 cm^3 Cylindrical Chamber	Cylindrical reference chamber, 31 mm diameter, for gamma radiation protection measurements in the energy range of 30 keV to 50 MeV. BNT, TNC or M connector	56
	34035	$H_p(10)$ Secondary Standard Chamber	Plane-parallel reference chamber embedded in an acrylic slab phantom for direct measurement of Personal Dose Equivalent $H_p(10)$. M or BNC/banana connector	57
	34014 786	Transmission Monitor Chambers for Calibration Benches	Circular transmission chambers of 155 mm resp. 148 mm sensitive diameter for radiation monitoring of calibration benches. BNT, TNC, M or BNC/banana connector	58
	7862	Transmission Monitor Chamber for X-ray Therapy Units	Circular transmission chamber of 96.5 mm sensitive diameter for radiation monitoring of X-ray therapy units. M or BNC/banana connector	59
	23392	Böhm Extrapolation Chamber	Precision extrapolation chamber with adjustable depth of the sensitive volume between 0.5 mm and 10.5 mm for dose measurements of Beta and soft X-rays. BNC sockets	60

Notes

Codes of Practice

Absorbed Dose Determination in Photon and High Energy Electron Beams

Based on Standards of Absorbed Dose to Water

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Disclaimer

Although the information in this document has been carefully assembled. PTW Freiburg does not guarantee that this document is free of errors. PTW Freiburg shall not be liable in any way for any consequence of using this document.

1 Introduction

This document constitutes an excerpt of procedures and data from various dosimetry protocols for the determination of absorbed dose to water using ionization chambers. As most modern dosimetry protocols (e.g. IAEA, AAPM, DIN) refer to ionization chambers calibrated in absorbed dose to water, this document does not describe dose determination with ionization chambers having other calibration factors.[1]

The chapters referring to high energy radiation describe the formalisms outlined in IAEA TRS-398, AAPM TG-51 and DIN 6800-2 as these dosimetry protocols are widely used, see references [IAEA 398], [AAPM 51/2] and [DIN 6800-2]. The chapter referring to kilovoltage X-ray beams describes only the formalism outlined in the DIN standards as IAEA TRS-398 differs only slightly from DIN, and AAPM TG-51 dose not address this energy range.

Although this document provides the reader with a concise overview of formulae and factors it shall not replace pertinent protocols and publications, nor is intended to give all of the details that are important for accurate dosimetry. Also, the procedures outlined in this document are not the only ones described in the referenced literature, they constitute only one of several possibilities for absorbed dose determination.

The present document is limited to

- the use of open (vented) ionization chambers
- the use of plane-parallel chambers in case of low energy X-ray beams and electrons
- the use of cylindrical chambers in case of medium energy X-ray beams
- PTW chambers, if factors are given that depend on the design of the ionization chamber.

NOTE
The terms 'Markus Chamber', 'Advanced Markus Chamber' and 'Roos Chamber' are the propriety of PTW Freiburg. The published data specific to these chambers are not valid for chambers manufactured by other companies, even if they are sold as 'Markus' or 'Roos' type chambers.

A summary of PTW chamber data is given in Appendix A.

[1] Document D560.210.00 refers to chambers calibrated in Air Kerma, Absorbed Dose to Air, and Exposure.

2 General Instructions

2.1 Corrected reading *M*

All formulae in this document used for the determination of absorbed dose to water D_w refer to a dosemeter reading M which is corrected for the influence quantities given in chapters 2.4 - 2.7. The reader must compute the corrected reading M from the uncorrected reading M_{uncorr} and the reading without irradiation M_0 by

$$M = (M_{uncorr} - M_0) \cdot k_{elec} \cdot k_{TP} \cdot k_S \cdot k_{pol} \cdot k_h \qquad (2\text{-}1)$$

The correction factor k_{elec} corresponds to the calibration factor of the electrometer if the electrometer readout is in terms of charge or current [IAEA 398, AAPM 51]. If the electrometer and the ionization chamber are calibrated together and the readout is in terms of Gy or Gy/s, a value of unity is to be used for k_{elec} . For PTW equipment k_{elec} = 1, except if otherwise stated in your calibration certificate.

The correction factors k_{TP} , k_S and k_h are described in chapters 2.4 - 2.7. For absorbed dose determination, additional factors are to be applied to the corrected reading M as described in chapters 3 - 6.

2.2 Measuring phantoms

This document assumes that all measurements are made in a water phantom, except for chapter 3.1 where the measurements are made at the surface of an acrylic (PMMA) phantom. If measurements are nevertheless made in other than water phantoms, the measures described in chapter 6 are to be taken. It should be noted, however, that most dosimetry protocols prescribe measurements in water only.

2.3 Chamber positioning

2.3.1 General rules

The dosemeter reading is obtained by positioning the ionization chamber at the point of interest in the phantom. Depending on the dosimetry protocol and radiation quality, either the effective point or the reference point of the ionization chamber is positioned at the point of interest. This document states the correct positioning method in each of the related chapters.

The reference point is defined as

- a point on the central axis of a cylindrical chamber as stated by the manufacturer. For PTW chambers, this is usually the center of the effective volume.
- a point on the inner surface of the entrance window, at the center of the window.

As a rule of thumb: to measure in the effective point of measurement, a thimble chamber has to be shifted away from the focus into the water. For plane-parallel chambers it is the opposite, they usually have to be shifted upwards towards the focus, or, for some protocols, they do not have to be shifted at all.

2.3.2 The TRUFIX system

The task of positioning various types of ionization chambers precisely in their effective point of measurement can be quite challenging. The patented TRUFIX system (see Figure 1) facilitates this task considerably. TRUFIX can be used on automated PTW water phantoms (MP2, MP3, BEAMSCAN etc.) in connection with most PTW therapy detectors. A plastic tip lets you easily locate the water surface where the coordinate system is set to (0,0,0) (when using the BEAMSCAN water phantom system, the water surface is located automatically). Then the plastic tip is replaced by a holding device specific to each detector type, and the effective point of measurement is automatically placed at the tip's earlier position. The radius of cylindrical chambers, the water-equivalent window thickness of plane-parallel chamber windows and the chamber centers are automatically accounted for.

Figure 1: The TRUFIX chamber positioning system for PTW BEAMSCAN (above) and other PTW Water phantoms (below).

2.4 Air density

2.4.1 The T&P method

Open (vented) ionization chambers must be corrected for air density according to [IAEA 398]

$$k_{TP} = \frac{P_0 \cdot (273.2 + T)}{P \cdot (273.2 + T_0)} \qquad (2\text{-}2)$$

T and P are the temperature and pressure in the measuring environment, the reference values are P_0 = 101.3 kPa and T_0 = 20 °C. Note that in some countries the reference temperature given in the calibration certificates is 22 °C instead of 20 °C. AAPM TG-51 uses a value of 22 °C as reference and a value of P_0 = 101.33 kPa for the reference pressure.

Care must be taken to ensure the use of correct values for the barometric pressure P existing in the measuring environment. Details can be found in the literature [Christ 2004].

The temperature should be measured in degrees Centigrade (°C) in the water, close to the detector and close in the time to the dose measurement.

Note, in some protocols, k_{TP} is designated as k_ρ.

2.5 Ion recombination

2.5.1 The two-voltage method

Correction factors for insufficient charge collection in the measuring volume of ionization chamber can be measured using the two-voltage method [IAEA 398, AAPM 51]. They depend on the geometry of the ionization chamber and on the dose rate or dose per pulse.

For pulsed or pulsed-scanned radiation the correction factor k_s can be determined from [IAEA 398]

$$k_s = \frac{\frac{M_1}{M_2} - 1}{\frac{V_1}{V_2} - 1} + 1 \qquad (2\text{-}3)$$

where M_1 and M_2 are the readings at two voltages V_1 and V_2. V_1 is the normally used voltage, and V_2 is a voltage reduced by a factor of at least 3.

Formula (2-3) is valid for $k_s < 1.03$. If $k_s \geq 1.03$ refer to chapter 2.5.2.

For continuous radiation k_s is taken from [IAEA 398]

$$k_s = \frac{\left(\frac{V_1}{V_2}\right)^2 - 1}{\left(\frac{V_1}{V_2}\right)^2 - \left(\frac{M_1}{M_2}\right)} \qquad (2\text{-}4)$$

Formula (2-3) assumes a linear relationship between $1/M$ and $1/V$, formula (2-4) a linear relationship between $1/M$ and $1/V^2$. New chambers should be tested in accordance with the following chapter.

2.5.2 Jaffé diagrams

A Jaffé diagram represents the inverse reading $1/M$ of an ionization chamber as a function of the inverse voltage $1/V$ ($1/V^2$ in case of continuous radiation). The reading M is corrected for polarity effect, i.e. M is the mean value of M_+ and M_-, see chapter 2.6. Figure 2 shows a Jaffé diagram for pulsed radiation with the axes normalized to the usual voltage V_1 and the corresponding reading M_1.

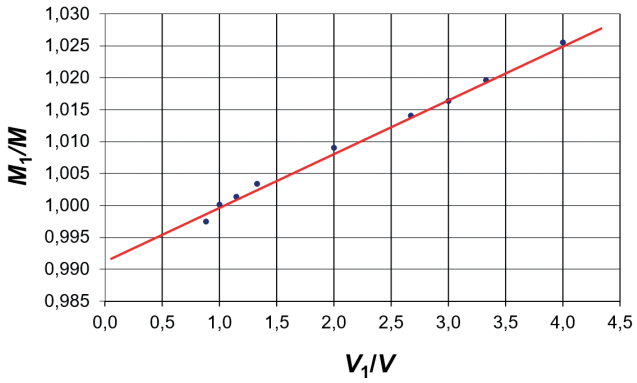

Figure 2: Jaffé diagram of a typical Farmer chamber usually operated at V_1 = 400 V. The regression line to the linear part intersects the M_1/M axis at 0.992 resulting in a correction factor k_s = 1/0.992 = 1.008. The dose per pulse was 0.974 mGy.

Figure 2: Jaffé diagram of a typical Farmer chamber usually operated at V_1 = 400 V. The regression line to the linear part intersects the M_1/M axis at 0.992 resulting in a correction factor k_S = 1/0.992 = 1.008. The dose per pulse was 0.974 mGy.
The useful range for the chamber voltage should be limited to the linear part of the Jaffé diagram which is generally approx. 1/3 of the nominal voltage [DIN 6800-2]. This document suggests to measure Jaffé diagrams at the lowest and at the highest dose per pulse or dose rate for each radiation quality, and to determine the linear range for the used ionization chamber from these diagrams.

The two-voltage method (see chapter 2.5.1) can be applied only if both voltages V_1 and V_2 are within the linear range of the Jaffé diagram. If this is not the case, the ionization chamber should be operated at the highest voltage of the linear range of the Jaffé diagram, and the correction factor k_S should be determined by extrapolating the linear part of the Jaffé diagram to an infinite voltage ($1/V = 0$). It should be noted that operating an ionization chamber at a voltage other than stated in the calibration certificate may cause an error as the calibration factor sometimes depends on the applied voltage.

2.5.3 The DPP method

If the dose per pulse (DPP) of the accelerator at the point of measurement is known, the correction factor can be calculated by [DIN 6800-2]

$$k_s = 1 + \frac{\gamma}{U} + \frac{\delta}{U} \cdot D_P \qquad (2\text{-}5)$$

D_P is the absorbed dose to water per accelerator pulse, expressed in mGy, U is the chamber voltage in V and the coefficients γ and δ are listed in Table 1 [DIN 6800-2]. Formula (2-5) is only valid if the frequency of the accelerator pulses is smaller than the reciprocal of the ion collection time.

Chamber type	γ ***V***	δ ***V* / mGy**	**Dose per pulse mGy**	**Chamber voltage *V***
PTW 30006/30013 Farmer	0.00	3.44	0.15 - 0.35 > 0.35 - 42	100 - 300 300 - 400
PTW 23331 1 cm³ Rigid Stem	0.00	5.68	0.25 - 2.1	50 - 400
PTW 23332 0.3 cm³ Rigid Stem	0.13	1.05	0.15 - 0.5 > 0.5 - 5.5	100 - 250 250 - 400
PTW 31002/31010 0.125 cm³ Semiflex	0.38	2.40	0.15 - 0.6 > 0.6 - 5.0	100 - 300 300 - 400
PTW 31013 Semiflex	0.35	3.3	0.1 - 0.8	300
PTW 31021 0.07 cm³ Semiflex 3D	0.15	2.69	0.2 - 3	400
PTW 31022 0.016 cm³ PinPoint 3D	0.38	1.02	0.2 - 3	300
PTW 34001 Roos	0.06	1.69	0.15 - 0.5 > 0.5 - 42	50 - 200 200 - 400
PTW 34045 Advanced Markus	0.43	0.49	0.5 - 1.0 > 1.0 - 5.5	50 - 200 200 - 300
PTW 23343 Markus	0.32	1.99	0.15 - 0.55 > 0.55 - 3.0	100 - 250 250 - 300

Table 1: Coefficients γ and δ for formula (2-5), applicable within the stated dose per pulse and voltage ranges, according to [DIN 6800-2].

2.6 Polarity effect

The polarity effect depends on the radiation beam quality Q. The correction factor for reference dosimetry can be determined by [IAEA 398, DIN 6800-2]

$$k_{pol} = \frac{\left[\frac{M_+ + M_-}{M_+}\right]_Q}{\left[\frac{M_+ + M_-}{M_+}\right]_{Co}} \qquad (2\text{-}6)$$

M_+ = positive reading obtained with the usual polarity

M_- = positive reading obtained with the opposite polarity

The index Co refers to the readings obtained in a ^{60}Co beam during calibration. If the data in ^{60}Co is not available, it can be measured in a ^{60}Co beam or requested from the calibration lab. Alternatively, as approximation, the radiation from a linear accelerator photon beam can be used, provided its nominal energy is 6 MV or below. The lower the beam energy, the better [DIN 6800-2].

2.7 Humidity

A correction factor for humidity has to be applied only if the ^{60}Co calibration factor refers to dry air [IAEA 398]:

$$k_h = 0.997 \qquad (2\text{-}7)$$

Usually the ^{60}Co calibration factor refers to a relative humidity of 50%; in this case k_h is taken as 1.000. This approximation is valid in the nominal range of humidity as defined in IEC 60731: 30% to 75% relative humidity and absolute humidity below 20 g/cm^3.

3 Kilovoltage X-Ray Beams

3.1 10 kV to 100 kV

$$D_W = k_Q \cdot N_W \cdot M \qquad (3\text{-}1)$$

D_w = absorbed dose to water [DIN 6809-4]

k_Q = energy dependent correction factor, given in the calibration certificate for several radiation qualities.

N_w = calibration factor for absorbed dose to water for the reference radiation quality stated in the calibration certificate

M = corrected reading of the dosemeter, see chapter 2.1. Measurements are to be made at the surface of an acrylic (PMMA) phantom. For measurements at other depths, water-equivalent material is to be added.

Influence Quantity	Reference Condition
Phantom material	PMMA
Chamber	plane-parallel, Type PTW 23342, 23344, or 34013
Depth	phantom surface
Chamber positioning	outer surface of entrance window
SDD	as stated in calibration certificate
Field size	as stated in calibration certificate, or 3 cm diameter at the measuring plane

NOTE
DIN 6809-4 suggests the use of a 0.1 mm water-equivalent plastic foil in front of the ionization chamber when measuring above 50 kV. This foil should provide adequate build-up and eliminate low energy electrons scattered upstream. IAEA TRS-398 suggests total material thickness (build-up foils plus entrance window) depending upon radiation quality (IAEA Table 8.1. Foil thickness should read µm). Ideally, the chamber and the build-up foils should be calibrated together, but this calibration is not available from PTW. If the user decides to use build-up foils, he should determine a correction factor for each beam geometry and radiation quality used.

3.2 100 kV to 300 kV

$$D_W = k_F \cdot k_Q \cdot N_W \cdot M \qquad (3\text{-}2)$$

D_w = absorbed dose to water [DIN 6809-4]

k_F = correction factor for field sizes other than 10 cm x 10 cm

k_Q = energy dependent correction factor, given in the calibration certificate for several radiation qualities

N_w = calibration factor for absorbed dose to water for ^{60}Co

M = corrected reading of the dosemeter, see chapter 2.1.

Influence Quantity	Reference Condition
Phantom material	water
Chamber	cylindrical
Depth	5 cm
Chamber positioning	chamber axis
SDD	100 cm
Field size	as stated in calibration certificate, or 10 cm x 10 cm at the phantom surface

4 High Energy Photon Beams

4.1 IAEA TRS-398

$$D_W = k_Q \cdot N_W \cdot M \qquad (4\text{-}1)$$

D_w = absorbed dose to water

k_Q = energy dependent correction factor, see Table 2 and 3

N_w = calibration factor for absorbed dose to water for ^{60}Co

M = corrected reading of the dosemeter, see chapter 2.1

Influence Quantity	Reference Condition
Phantom material	water
Chamber	cylindrical
Depth	10 g · cm^{-2} (or 5 g · cm^{-2}) for $TPR_{20,10} < 0.7$ 10 g · cm^{-2} for $TPR_{20,10} \geq 0.7$
SSD / SDD	100 cm
Field size	10 cm x 10 cm SSD setup: field size defined at surface SDD setup: field size defined in detector plane

The tissue phantom ratio $TPR_{20,10}$ is measured for each nominal accelerating voltage. $TPR_{20,10}$ is defined as the ratio M_{20} / M_{10} of two ionization readings of a dosemeter at different depths. M_{20} is obtained at 20 cm depth of water, M_{10} at 10 cm depth of water at a fixed source-detector-distance SDD = 100 cm and a field size of 10 cm x 10 cm at the depth of measurement.

NOTE

In case $TPR_{20,10}$ values are not available, they can be determined from a PDD[2] measurement [IAEA 398]

$$TPR_{20,10} = 1.2661 \cdot PDD_{20,10} - 0.0595 \qquad (4\text{-}2)$$

where $PDD_{20.10}$ is the ratio of the percent depth doses at 20 cm and 10 cm depth, respectively. The PDD values must be measured at SSD = 100 cm with a field size of 10 cm x 10 cm at the phantom surface. Please note, this formula has been validated for flattened photon beams only.

Chamber positioning

For beam quality specification measurements and for reference dosimetry with a cylindrical chamber, the chamber axis should be positioned at the measuring depth.

For PDD measurements with a cylindrical chamber in MV photon beams, the effective point of measurement should be positioned in the depth of interest. To do this, shift the chamber by 0.6·r into the water (i.e. away from the linac head), where r is the inner radius of the measuring volume.

For plane-parallel chambers the reference point should be positioned into the depth of interest for all of the above measurements. If highest accuracy is required, the water-equivalent window thickness of the chamber should be considered. But this effect is very small and can be neglected in practice.

[2] PDD stands for "percentage depth dose".

Photon Beam Quality $TPR_{20,10}$	PTW 23331 1.0 cm³ Rigid Stem	PTW 23332 0.3 cm³ Rigid Stem	PTW 23333/ 30001/ 30010 Farmer	PTW 30002/ 30011 Farmer	PTW 30004/ 30012 Farmer	PTW 30006/ 30013 Farmer	PTW 31002 0.125cm³ Semiflex	PTW 31003 0.3cm³ Semiflex	PTW 31014/ 31015 PinPoint
0.50	1.004	1.004	1.004	1.006	1.006	1.002	1.003	1.003	1.004
0.53	1.003	1.003	1.003	1.004	1.005	1.002	1.002	1.002	1.003
0.56	1.000	1.001	1.001	1.001	1.002	1.000	1.000	1.000	1.001
0.59	0.999	0.999	0.999	0.999	1.000	0.999	0.999	0.999	0.999
0.62	0.997	0.997	0.997	0.997	0.999	0.997	0.997	0.997	0.998
0.65	0.993	0.994	0.994	0.994	0.996	0.994	0.994	0.994	0.995
0.68	0.990	0.990	0.990	0.992	0.994	0.990	0.990	0.990	0.992
0.70	0.988	0.988	0.988	0.990	0.992	0.988	0.988	0.988	0.989
0.72	0.985	0.984	0.985	0.987	0.989	0.984	0.984	0.984	0.985
0.74	0.982	0.980	0.981	0.984	0.986	0.980	0.980	0.980	0.980
0.76	0.978	0.976	0.976	0.980	0.982	0.975	0.975	0.975	0.975
0.78	0.971	0.968	0.969	0.973	0.976	0.968	0.968	0.968	0.967
0.80	0.964	0.961	0.962	0.967	0.969	0.960	0.960	0.960	0.959
0.82	0.956	0.954	0.955	0.959	0.962	0.952	0.952	0.952	0.952
0.84	0.945	0.943	0.943	0.948	0.950	0.940	0.940	0.940	0.941

Table 2: Typical k_Q values for PTW cylindrical chambers [IAEA 398], [IAEA 398/2]. For ^{60}Co beams k_Q is 1.000. The PinPoint chamber type 31015 has been added by PTW Freiburg.

Chamber Type	Chamber-type specific parameters	
	a	***b***
PTW 30010 Farmer	1.12 594	-0.10 740
PTW 30011 Farmer	1.10 850	-0.10 107
PTW 30012 Farmer	1.12 442	-0.10 415
PTW 30013 Waterproof Farmer	1.18 273	-0.13 256
PTW 31003/31013 Semiflex	1.19 297	-0.13 366
PTW 31010 Semiflex	1.23 755	-0.15 295
PTW 31016 PinPoint 3D	1.11 650	-0.10 841
PTW 31021 Semiflex 3D	1.29 612	-0.16 514
PTW 31022 PinPoint 3D	1.14 435	-0.11 1303

Table 3: Fit parameters for k_Q values for PTW chambers. k_Q is obtained from the formula (4-3) [Andreo 2020]. The data for the 31022 PinPoint 3D has been added by PTW Freiburg [Report PTW].

$$k_Q(TPR_{20,10}) = \frac{1 + \exp\left(\frac{a - 0.57}{b}\right)}{1 + \exp\left(\frac{a - TPR_{20,10}}{b}\right)} \qquad (4\text{-}3)$$

4.2 AAPM TG-51 (1999 and 2014)

$$D_W = k_Q \cdot N_W \cdot P_{rp} \cdot M \qquad (4\text{-}4)$$

D_w = absorbed dose to water

k_Q = energy dependent correction factor, see Table 3a, 3b. The values can be used for both flattened and flattening filter free beams

N_w = calibration factor for absorbed dose to water for ^{60}Co

P_{rp} = correction factor for beams which are not flat over the volume of the chamber. In most cases, this applies to FFF beams

M = corrected reading of the dosemeter, see chapter 2.1. In non-uniform beams, e.g. FFF beams, the reading must be averaged over the dimensions of the active volume of the ionization chamber

Influence Quantity	Reference Condition
Phantom material	water
Chamber	cylindrical, PTW chambers as listed in Table 3a or 3b
Depth	10 cm
SSD / SDD	100 cm
Field size	10 cm x 10 cm SSD setup: field size defined at surface SDD setup: field size defined in detector plane

Chamber positioning

For reference dosimetry with a cylindrical chamber, the chamber axis should be positioned at the measuring depth.

For the determination of the beam quality specifier and for PDD measurements in MV photon beams, the effective point of measurement should be positioned into the depth of interest. To do this, shift the chamber by 0.6**r* into the water (i.e. away from the linac head), where *r* is the inner radius of the measuring volume.

For plane-parallel chambers the reference point should be positioned into the depth of interest for all of the above measurements.

Measurement of the beam quality specifier

The beam quality specifier $\%dd(10)_X$ is the percentage depth dose at 10 cm depth in a water phantom due to photons only. $\%dd(10)_X$ is defined at *SSD* = 100 cm for a field size of 10 cm x 10 xm at the phantom surface.

When measuring a depth dose curve for the determination of $\%dd(10)_X$ a lead foil should be used

I) at energies about 10 MV and above if highest precision is desired

II) for measurements of flattening filter free (FFF) beams at all energies.

The lead foil should be 1 mm in thickness (± 20 %) and it should be placed (50 ± 5) cm or, if this is not possible, (30 ± 1) cm above the phantom surface.

The beam quality specifier is obtained from the corresponding value $\%dd(10)_{Pb}$ by one of the following formulae

lead foil at (50 ± 5) cm and $\%dd(10)_{Pb} \geq 73\,\%$

$$\%dd(10)_x = (0.8905 + 0.00150 \cdot \%dd(10)_{Pb}) \cdot \%dd(10)_{Pb} \qquad (4\text{-}5)$$

lead foil at (30 ± 1) cm and $\%dd(10)_{Pb} \geq 71\,\%$

$$\%dd(10)_x = (0.8116 + 0.00264 \cdot \%dd(10)_{Pb}) \cdot \%dd(10)_{Pb} \qquad (4\text{-}6)$$

If $\%dd(10)_{Pb}$ is below the above thresholds, $\%dd(10)_X$ equals $\%dd(10)_{Pb}$.

Note, [AAPM 51/2] recommends not to use the lead foil for beams **with** flattening filter. Instead the conversion formula No 15 from [AAPM 51] should be used and an additional 0.2% uncertainly added to the uncertainly budget of k_Q. The beam specifier $\%dd(10)_X$ is then calculated from the open beam measurement $\%dd(10)$ as:

$$\%dd(10)_x = 1.267 \cdot \%dd(10) - 20.0 \qquad (4\text{-}7)$$

It is valid for $\%dd(10)$ between 75 % and 89 %. For flattening filter free beams, [AAPM 51/2] recommends to use the lead foil as described above.

NOTE
The lead foil is used for beam quality specification only. Remove the lead foil for dose measurements.

Calculation of P_{rp}

Guidance on the calculation of P_{rp} can be found in section 4.5 of:
Muir, B. et al. (2022). AAPM WGTG51 Report 374: Guidance for TG-51 reference dosimetry. Medical Physics. https://doi.org/10.1002/mp.15949

Chamber Type	Photon Beam Quality $\%dd(10)_x$					
	58	63	66	71	81	93
PTW 30001/ 30006 Farmer	1	0.996	0.992	0.984	0.967	0.945
PTW 30002 Farmer	1	0.997	0.994	0.987	0.970	0.948
PTW 30004 Farmer	1	0.998	0.995	0.988	0.973	0.952
PTW 30010 Farmer	1	0.997	0.993	0.986	0.968	-
PTW 30011 Farmer	1	0.997	0.994	0.986	0.969	-
PTW 300012 Farmer	1	0.998	0.995	0.988	0.971	-
PTW 30013 Waterproof Farmer	1	0.996	0.992	0.985	0.967	-
PTW 31003/31013 Semiflex	1	0.997	0.993	0.986	0.967	-
PTW 31021 Semiflex 3D	1	0.996	0.992	0.985	0.967	-

Table 3a: Typical k_Q values for PTW cylindrical chambers [AAPM 51], [AAPM 51/2]. For ^{60}Co beams k_Q is 1.000. [AAPM 51/2] does not recommend the 0.125 cm^3 Semiflex chambers PTW 31002 and 31010 as reference class chambers. PTW suggests the use of the same k_Q values as for the 0.3 cm^3 Semiflex chamber PTW 31013. The data for the 31021 Semiflex 3D has been added by PTW Freiburg [Kawachi 2019] [Report OL].

Chamber Type	*A*	*B*	*C*
PTW 30010 Farmer	1.0093	0.926	-1.771
PTW 30011 Farmer	0.9676	2.061	-2.528
PTW 30012 Farmer	0.9537	2.440	-2.750
PTW 30013 Waterproof Farmer	0.9652	2.141	-2.623
PTW 31003/31013 Semiflex	0.9725	1.957	-2.498
PTW 31021 Semiflex 3D	0.9874	1.420	-2.056

Table 3b: Fit parameters for k_Q values for PTW cylindrical chambers [AAPM 51/2]. The parameters for the 31021 Semiflex 3D has been added by PTW Freiburg [Kawachi 2019] [Report OL]. k_Q is obtained from the formula (4-8) which holds for beam specifiers between 63 % and 86 %.

$$k_Q = A + B \cdot 10^{-3} \cdot \%dd(10)_x + C \cdot 10^{-5} \cdot (\%dd(10)_x)^2 \quad (4\text{-}8)$$

4.3 DIN 6800-2:2020

$$D_W = k_r \cdot k_{Q,M} \cdot N_W \cdot M \qquad (4\text{-}9)$$

D_w = absorbed dose to water

k_r = replacement correction factor, see Table 4

$k_{Q,M}$ = energy dependent correction factor, see section 4.3.3

N_w = calibration factor for absorbed dose to water for ^{60}Co

M = corrected reading of the dosemeter, see chapter 2.1.

Influence Quantity	Reference Condition
Phantom material	water
Chamber	cylindrical
Depth	5 cm for ^{60}Co 10 cm for photons of MV energies
Chamber positioning	effective point of measurement, see chapter 4.3.1
SSD	95 cm for ^{60}Co 100 cm for MV photons
Field size	10 cm x 10 cm at 5 cm depth for ^{60}Co 10 cm x 10 cm at phantom surface for MV photons
Field shape in the beam center	In the center of the beam the field should be flat (i.e. no flattening filter free beams)

4.3.1 Chamber positioning

For all measurements including reference dosimetry and relative dosimetry, all detectors should be positioned with their effective point of measurement at the depth of interest. To do this, the chamber must be shifted by Δz away from its reference point. If Δz is positive, the chamber must be shifted into the water (away from the linac head) and if Δz is negative it must be shifted out of the water (towards the linac head). As a rule of thumb, thimble chambers usually must be shifted into the water while plane-parallel chambers usually must be shifted out of the water. Values for the shift Δz and the respective correction factor k_r are given in Table 4. Note, for thimble chambers, the shift Δz can be calculated as $\Delta z = 0.5 * r$, where r is the inner radius of the measuring volume.

4.3.2 Beam quality determination

The beam quality index Q is to be measured for each nominal beam energy. It is determined from a PDD measurement [DIN 6800-2] using:

$$Q = 1.2661 \cdot \frac{M_{20}}{M_{10}} - 0.0595 \qquad (4\text{-}10)$$

where M_{10} and M_{20} are the measured values of the percent depth doses in 10 cm and 20 cm depth, respectively. The percent depth doses must be measured at SSD = 100 cm with a field size of 10 cm x 10 cm at the phantom surface.

It is allowed to use a plane-parallel chamber to determine the beam quality.

4.3.3 Beam quality correction factor

The beam quality correction factor is given by

$$k_{Q,M} = k_{Q,R} \cdot k_{NR,Q} \qquad (4\text{-}11)$$

where $k_{Q,R}$ is the beam quality correction factor under reference conditions, and $k_{NR,Q}$ is an additional correction factor for non-reference conditions. Under reference conditions $k_{NR,Q} = 1$.

$k_{Q,R}$ is calculated according to

$$k_{Q,R} = \frac{1 + e^{A \cdot (0.57 - Q_0)}}{1 + e^{A \cdot (Q - Q_0)}} \qquad (4\text{-}12)$$

where A and Q_0 depend on the detector used and are given in Table 5. Eq. (4-12) is valid for $0.50 \le Q \le 0.84$ for cylindrical chambers and $0.62 \le Q \le 0.81$ for plane-parallel chambers.

4.3.4 Reference dosimetry at flattening filter free (FFF) beams

For reference dosimetry in flattening filter free (FFF) beams, $k_{NR,Q}$ is no longer equal to 1. There are two methods to calculate it which are described in the following. In both cases you need to calculate a volume correction in inplane and crossplane direction – more precisely in the direction parallel to the chamber axis and perpendicular to it. $k_{NR,Q}$ is then given by

$$k_{NR,Q} = p_{V,parallel} \cdot p_{V,perpendicular} \qquad (4\text{-}13)$$

p_V can be calculated by the following two methods:

Method 2 is similar to method 1 only that the same detector is used to scan the profile and to measure the reference dose.

Method 1

1. Determine the true profile using a high resolution detector, such as microDiamond, a silicon diode or a PinPoint 3D chamber.

2. Fit a sixth order polynomial to the central part of the profile using

$$D(x) = a_0 + a_2 x^2 + a_4 x^4 + a_6 x^6 \quad (4\text{-}14)$$

3. For reference dosimetry in the center of a FFF beam, p_V is then calculated by

$$p_V = \frac{1}{1 + \frac{a_2 \sigma^2 + 3 a_4 \sigma^4 + 15 a_6 \sigma^6}{a_0}} \quad (4\text{-}15)$$

where σ depends on the orientation of the chamber and is given in Table 6.

Method 2

1. Determine the non-perfect profile using one of the detectors listed in Table 6.

2. Fit a sixth order polynomial to the central part of the profile using

$$D(x) = b_0 + b_2 x^2 + b_4 x^4 + b_6 x^6 \quad (4\text{-}16)$$

3. For reference dosimetry in the center of a FFF beam, p_V is then calculated by

$$p_V = 1 - \frac{b_2}{b_0} \sigma^2 + 3 \frac{b_4}{b_0} \sigma^4 - 15 \frac{b_6}{b_0} \sigma^6 \quad (4\text{-}17)$$

Chamber Type	Radius r [mm]	Correction factor k_r
PTW 30010/30013 0.6 cm³ Farmer	3.05	1.009 2
PTW 31021 0.07 cm³ Semiflex 3D	2.40	1.007 3
PTW 31010 0.125 cm³ Semiflex	2.75	1.008 3
PTW 31013 0.3 cm³ Semiflex	2.75	1.008 3
PTW 23331/30015 1.0 cm³ Rigid Stem	3.95	1.012 0
PTW 23332/30016 0.3 cm³ Rigid Stem	2.50	1.007 6
PTW 31014/31023 0.015 cm³ PinPoint	1.00	1.003 0
PTW 31016/31022 0.016 cm³ PinPoint 3D	1.45	1.004 4
PTW 23343 Markus	-	0.998 2
PTW 34001 Roos	-	0.997 6
PTW 34045 Advanced Markus	-	1.000 0

Table 4: Radius of the measuring volume of PTW chambers and values for the correction factor k_r [DIN 6800-2].
For details on the chambers see Appendix A.

Chamber Type	A	Q_0
$0.50 \leq Q \leq 0.84$		
PTW 23331/30015 1.0 cm³ Rigid Stem	8.7138	1.1469
PTW 23332/30016 0.3 cm³ Rigid Stem	8.7357	1.1439
PTW 30001 0.6 cm³ Farmer	9.8877	1.1032
PTW 30006/30013 0.6 cm³ Farmer	9.6727	1.1045
PTW 30010 0.6 cm³ Farmer	9.8877	1.1032
PTW 31002 0.125 cm³ Semiflex	9.3332	1.1202
PTW 31003 0.3 cm³ Semiflex	9.3332	1.1202
PTW 31006 0.015 cm³ PinPoint	10.0559	1.1052
PTW 31010 0.125 cm³ Semiflex	9.0531	1.1243
PTW 31013 0.3 cm³ Semiflex	9.3332	1.1202
PTW 31014 0.015 cm³ PinPoint	8.5021	1.1378
PTW 31016 0.016 cm³ PinPoint 3D	8.6529	1.1305
PTW 31021 0.07 cm³ Semiflex 3D	7.0300	1.2396
PTW 31022 0.016 cm³ PinPoint 3D	3.3424	1.5606
$0.62 \leq Q \leq 0.81$		
PTW 23343 Markus	15.1234	1.0099
PTW 34001 Roos	12.1956	1.0463
PTW 34045 Advanced Markus	12.1083	1.0516

Table 5: Constant A and Q_0 which are required to calculate $k_{Q,R}$ according to eq. (4-12) [DIN 6800-2].
The given values are valid for $0.50 \leq Q \leq 0.84$ for cylindrical chambers and $0.62 \leq Q \leq 0.81$ for plane-parallel chambers.

Chamber Type	σ perpendicular to detector axis		σ along to detector axis	
	6 MV	15 MV	6 MV	15 MV
PTW 31002/31010 Semiflex	2.20	2.30	2.28	2.50
PTW 31003/31013 Semiflex	2.41	2.44	4.87	5.05
PTW 31014 PinPoint	0.99	0.99	1.98	2.02
PTW 31015 PinPoint	1.40	1.49	2.23	2.30
PTW 31016 PinPoint 3D	1.38	1.38	1.79	1.90
PTW 31021 Semiflex 3D	2.10	2.10	2.10	2.10

Table 6: σ values for PTW cylindrical chambers [DIN 6800-2] [Delfs2018].

5 High Energy Electron Beams

5.1 IAEA TRS-398 (2000)

5.1.1 Chambers calibrated at ^{60}Co

$$D_W = k_Q \cdot N_W \cdot M \qquad (5\text{-}1)$$

D_w = absorbed dose to water

k_Q = energy dependent correction factor, see Table 7

N_w = calibration factor for absorbed dose to water for ^{60}Co

M = corrected reading of the dosemeter, see chapter 2.1.

Influence Quantity	Reference Condition
Phantom material	water (for beams with $R_{50} < 4$ g/cm^2 (approx. $E_0 \geq 10$ MeV) a plastic phantom may be used)
Chamber	plane-parallel (for beams with $R_{50} \geq 4$ g/cm^2 (approx. $E_0 \geq 10$ MeV) a cylindrical chamber may be used)
Depth	$z_{ref} = 0.6 \cdot R_{50} - 0.1$ g/cm^2 (z_{ref} and R_{50} in g/cm^2)
Chamber positioning	see chapter 5.1.2
SSD	100 cm
Field size	10 cm x 10 cm at phantom surface, or that used for normalization of output factors, whichever is larger

5.1.2 Chamber positioning

When using a plane-parallel chamber, the reference point should be positioned in the depth of interest. If highest accuracy is required, the water-equivalent window thickness of the chamber can be considered. But this effect is very small and can be neglected in practice.

For beam quality specification measurements with a cylindrical chamber, the chamber axis must be shifted into the water (away from the linac head) by 0.5 r, where r is the inner radius of the measuring volume. The same shift is used when performing reference dosimetry.

5.1.3 Beam quality measurement

The beam quality is specified by R_{50}, the depth in water at which the absorbed dose is 50% of its value at the absorbed dose maximum[3]. R_{50} is to be measured under the above reference conditions, but a field sizes of at least

10 cm x 10 cm for $R_{50} \leq 7$ g/cm^2

20 cm x 20 cm for $R_{50} > 7$ g/cm^2

From the depth ionization distribution measured with an air-filled ionization chamber, the quantity $R_{50,ion}$ is obtained. This quantity can be converted to R_{50} by

$$R_{50} = 1.029 \cdot R_{50,ion} - 0.06 \text{ g/cm}^2 \qquad (5\text{-}2)$$
($R_{50,ion} \leq 10$ g/cm^2)

$$R_{50} = 1.059 \cdot R_{50,ion} - 0.37 \text{ g/cm}^2 \qquad (5\text{-}3)$$
($R_{50,ion} > 10$ g/cm^2)

For $R_{50} \leq 4$ g/cm^2 a plane-parallel chamber must be used.

5.1.4 Cross-Calibration

IAEA TRS-398 recommends the cross-calibration of plane-parallel chambers against a cylindrical chamber which is calibrated at ^{60}Co. The cross-calibration measurement is performed under reference conditions (see chapter 5.1.1) using the highest available electron energy Q_{cross}.

[3] The mean energy E_0 can be estimated by $E_0 = 2.33 \cdot R_{50}$ (R_{50} in g/cm^3 and E_0 in MeV).

Step 1: measure a reference dose $D_{w,Qcross}$ with a cylindrical chamber which was calibrated at ^{60}Co, following the procedure described in chapter 5.1.1.

Step 2: irradiate the plane-parallel chamber with the same dose. Take the plane-parallel chamber's corrected reading M and determine its calibration factor for the energy used for cross-calibration

$$N_{W,Q_{cross}} = \frac{D_{W,Q_{cross}}}{M} \qquad (5\text{-}4)$$

Step 3: use the cross-calibrated plane-parallel chamber to measure dose at any electron energy Q other than Q_{cross}

$$D_W = \frac{k_Q}{k_{Q_{cross}}} \cdot N_{W,Q_{cross}} \cdot M \qquad (5\text{-}5)$$

k_{Qcross} is the plane-parallel chamber's k_Q value for the cross-calibration energy Q_{cross}. Values for k_Q are obtained from Table 7.

Electron Beam Quality *R* [g/cm²]	PTW 23343 Markus	PTW 34045 Advanced Markus	PTW 34001 Roos	PTW 30001/ 30010 Farmer	PTW 30002/ 30011 Farmer	PTW 30004/ 30012 Farmer	PTW 30006/ 30013 Farmer	PTW 31002/ 31010 0.125 cm³ Semiflex	PTW 31003/ 31013 0.3 cm³ Semiflex
1.0	-	0.966	0.965	-	-	-	-	-	-
1.4	-	0.956	0.955	-	-		-	-	-
2.0	0.925	0.945	0.944	-	-	-	-	-	-
2.5	0.920	0.938	0.937	-	-	-	-	-	-
3.0	0.916	0.932	0.931	-	-	-	-	-	-
3.5	0.913	0.926	0.925	-	-	-	-	-	-
4.0	0.910	0.921	0.920	0.911	0.916	0.920	0.911	0.912	0.912
4.5	0.907	0.917	0.916	0.909	0.914	0.918	0.909	0.910	0.910
5.0	0.904	0.912	0.912	0.907	0.912	0.916	0.907	0.908	0.908
5.5	0.901	0.909	0.908	0.905	0.910	0.915	0.906	0.906	0.906
6.0	0.899	0.905	0.904	0.904	0.909	0.913	0.904	0.905	0.905
7.0	0.894	0.899	0.898	0.901	0.906	0.910	0.901	0.901	0.901
8.0	0.889	0.893	0.892	0.898	0.903	0.907	0.898	0.898	0.898
10.0	0.881	0.883	0.882	0.893	0.897	0.902	0.893	0.893	0.893
13.0	0.870	0.871	0.870	0.885	0.890	0.894	0.885	0.885	0.885
16.0	0.860	0.861	0.860	0.877	0.882	0.887	0.878	0.877	0.877
20.0	0.849	0.849	0.848	0.868	0.873	0.877	0.868	0.867	0.867

Table 7: Typical k_Q values for PTW plane-parallel and cylindrical chambers [IAEA 398][4]. The values for the Advanced Markus chamber and the Farmer chambers type 30006/300133 have been added by PTW Freiburg. They were calculated according to IAEA TRS-398[5].

[4] With corrigendum STI/DOC/010/398

[5] For details refer to PTW's Technical Note D661.200.00

5.2 AAPM TG-51 (1999 and 2014)

5.2.1 Chambers calibrated at ^{60}Co

$$D_W = P_{gr}^{Q} \cdot k'_{R_{50}} \cdot k_{ecal} \cdot N_W \cdot M \qquad (5\text{-}6)$$

D_w = absorbed dose to water

P_{gr}^{Q} = correction for gradient effects, not needed for plane-parallel chambers. For cylindrical chambers with a cavity radius r the correction factor at the reference depth d_{ref} is obtained from

$$P_{gr}^{Q} = \frac{M\,(d_{ref} + 0.5 \cdot r)}{M\,(d_{ref})}$$

$k'_{R_{50}}$ = electron quality conversion factor, see formulae (5-9) and (5-10)

k_{ecal} = photon-electron conversion factor, see Table 8

N_w = calibration factor for absorbed dose to water for ^{60}Co

M = corrected reading of the dosemeter, see chapter 2.1.

Influence Quantity	Reference Condition
Phantom material	water
Chamber	plane-parallel preferred for $R_{50} \le 4$ g/cm^2 (10 MeV) plane-parallel mandatory for $R_{50} \le 2.6$ cm (6 MeV)
Depth	$d_{ref} = 0.6 \cdot R_{50} - 0.1$ cm
Chamber positioning	the reference point of the detector should be placed in the depth of interest. This is the case for cylindrical chambers as well as plane-parallel chambers.
SSD	90 -100 cm
Field size	≥ 10 cm x 10 cm at phantom surface for $R_{50} \le 8.5$ cm (20 MeV) ≥ 20 cm x 20 cm at phantom surface for $R_{50} > 8.5$ cm

The beam quality is specified by R_{50}, the depth in water at which the absorbed dose is 50% of its value at the absorbed dose maximum. R_{50} is to be measured under the above reference conditions, but at *SSD* = 100 cm and at field sizes at the phantom surface of at least

10 cm x 10 cm for $R_{50} \le 8.5$ cm

20 cm x 20 cm for $R_{50} > 8.5$ cm

From the depth ionization distribution measured with an air-filled ionization chamber, the quantity I_{50} is obtained. This quantity can be converted to R_{50} by

$$R_{50} = 1.029 \cdot I_{50} - 0.06\,\text{cm} \qquad (2 \le I_{50} \le 10\ \text{cm}) \qquad (5\text{-}7)$$

$$R_{50} = 1.059 \cdot I_{50} - 0.37\,\text{cm} \qquad (I_{50} > 10\ \text{cm}) \qquad (5\text{-}8)$$

Chamber Type	k_{ecal}
PTW 34001 Roos	0.901
PTW 34045 Advanced Markus	0.905
PTW 23343 Markus	0.905
PTW 3001/30010 Farmer	0.897
PTW 30002/30011 Farmer	0.900
PTW 30004/30012 Farmer	0.905
PTW 30006/30013 Farmer	0.896
PTW 31003/31013 0.3 cm^3 Semiflex	0.898
PTW 31002/31010 0.125 cm^3 Semiflex	0.898
PTW 2331 1.0 cm^3 Rigid Stem	0.896
PTW 23332/30016 0.3 cm^3 Rigid Stem	0.898

Table 8: Values of the photon-electron conversion factor k_{ecal}. The values not listed in [AAPM 51] have been added by PTW Freiburg; they were calculated according to [Rogers 1998].

For beam quality specification measurements with a cylindrical chamber, the chamber axis must be shifted into the water (away from the linac head) by $0.5 \cdot r$, where r is the inner radius of the measuring volume. Cylindrical chambers should be used only for $R_{50} > 4.3$ cm.

The electron quality conversion factor is obtained from the following formulae with R_{50} expressed in cm.

For cylindrical chambers and $2 \le R_{50} \le 9$ cm

$$k'_{R_{50}} = 0.9905 + 0.0710 \cdot e^{-\frac{R_{50}}{3.67}} \qquad (5\text{-}9)$$

and for well-guarded plane-parallel chambers and $2 \le R_{50} \le 20$ cm

$$k'_{R_{50}} = 1.2239 - 0.145 \cdot (R_{50})^{0.214} \qquad (5\text{-}10)$$

5.2.2 Cross-calibration

AAPM TG-51 recommends the cross-calibration of plane-parallel chambers against a cylindrical chamber which is calibrated at ^{60}Co. Dose measurements are performed under the reference conditions (see chapter 5.2.1) using the highest available electron energy Q_{cross}.

Step 1: measure a reference dose $D_{W,Qcross}$ with a cylindrical chamber which was calibrated at ^{60}Co, following the procedure described in chapter 5.2.1.

Step 2: irradiate the plane-parallel chamber with the same dose. Take the plane-parallel chamber's corrected reading M and determine its calibration factor for the energy used for cross-calibration

$$N_{W,Q\,cross} = \frac{D_{W,Q_{cross}}}{M} \qquad (5\text{-}11)$$

Step 3: use the cross-calibrated plane-parallel chamber to measure dose at any electron energy Q other than Q_{cross}

$$D_W = \frac{k'_{R_{50}}}{k'_{R_{50},Q_{cross}}} \cdot N_{W,Q_{cross}} \cdot M \qquad (5\text{-}12)$$

$k'_{R50.Qcross}$ is the plane-parallel chamber's k'_{R50} value for the cross-calibration energy Q_{cross}.
k'_{R50} values are obtained from formula (5-10).

5.3 DIN 6800-2:2020

5.3.1 Chambers calibrated at ^{60}Co

$$D_W = k_r \cdot k_{E,M} \cdot N_W \cdot M \qquad (5\text{-}13)$$

D_w = absorbed dose to water at z_{ref}

k_r = Replacement correction factor

$k_{E,M}$ = $k_{E,R} \cdot k_{N,R,E}$ energy dependent correction factor, see chapter 5.3.4

N_w = calibration factor for absorbed dose to water for ^{60}Co

M = corrected reading of the dosemeter at z_{ref}, see chapter 2.1.

Influence Quantity	Reference Condition
Phantom material	water
Chamber	plane-parallel
Depth	z_{ref} (see chapter 5.3.3)
Chamber positioning	effective point of measurement, see chapter 5.3.2
SSD	100 cm
Field size	20 cm x 20 cm at phantom surface for R_{50} > 7 cm and 10 cm x 10 cm for $R_{50} \leq 7$ cm

5.3.2 Chamber positioning

The positioning of chambers is the same as for photon dosimetry, see chapter 4.2.1.

5.3.3 Determination of R_{50} and z_{ref}

R_{50} is defined as the depth at which the absorbed dose has dropped to 50% of the maximum value. R_{50} is determined from the corresponding value $R_{50,ion}$ of a depth ionization curve, measured at SSD = 100 cm with a field size of 20 cm x 20 cm for R_{50} > 7 cm and 10 cm x 10 cm for $R_{50} \leq 7$ cm

$$R_{50} = 0.00171\ \text{cm}^{-1} \cdot R_{50,ion}^2 + 1.00805 \cdot R_{50,ion} - 0.00689\ \text{cm} \qquad (5\text{-}14)$$

The measurement has to be performed with a plane-parallel chamber, corrected for polarity and saturation effects. The reference depth for dose measurements is defined as (z_{ref} and R_{50} in cm)

$$z_{ref} = 0.6 \cdot R_{50} - 0.1\ \text{cm} \qquad (5\text{-}15)$$

5.3.4 Determination of $k_{E,M} = k_{E,R} \cdot k_{NR,E}$

Under reference conditions, $k_{NR,E} = 1$ and hence $k_{E,M} = k_{E,R}$.

In the current version of DIN6800-2:2020, the factors necessary to calculate $k_{E,R}$ are only available for plane-parallel chambers. For these chambers, it is calculated by

$$k_{E,R} = A + B\, e^{-\frac{R_{50}}{C}} \qquad (1.8\ \text{cm} \le R50 \le 8.8\ \text{cm}) \qquad (5\text{-}16)$$

Values for A, B and C are given in Table 9.

Chamber type	A	B	C
PTW 34001 Roos	0.8858	0.1206	3.511
PTW 34045 Adv. Markus	0.8864	0.1214	3.349
PTW 23343 Markus	0.8852	0.1008	3.826

Table 9: Constants to calculate the beam quality correction for plane-parallel chambers at the reference depth z_{ref} [DIN6800-2].

5.3.5 Dose measurements at depths other than z_{ref}

At depths other than z_{ref}, $k_{NR,E}$ is no longer equal to 1 but depends on the measurement depth:

$$k_{NR,E} = \frac{s^{\triangle}_{w,a}(z, R_{50})}{s^{\triangle}_{w,a}(z_{ref}, R_{50})} \qquad (5\text{-}17)$$

To determine $s^{\triangle}_{w,ab}$ in the reference depth z_{ref}, you can use

$$s^{\triangle}_{w,a}(z_{ref}, R_{50}) = 1.253 - 0.1487 \cdot (R_{50})^{0.214} \qquad (5\text{-}18)$$

In all other depths, it is calculated by

$$s^{\triangle}_{w,a}(z, R_{50}) = \frac{a + bx + cx^2 + dy}{1 + ex + fx^2 + gx^3 + hy} \qquad (5\text{-}19)$$

where $x = ln(R_{50}/1\text{cm})$ and $y = z/R_{50}$ (z and R_{50} in cm) and

$a = 1.0752$ $b = 0.50867$ $c = 0.08867$

$d = -0.08402$ $e = -0.42806$ $f = 0.06463$

$g = 0.003085$ $h = -0.1246$

5.3.6 Dose measurements at other field sizes than the reference field size

The measurement depth z_{ref} of the reference field size should be used for all field sizes.

Note, DIN 6800-2:2020 is only valid down to field sizes of 6 cm x 6 cm for electron dosimetry.

6 Measurements in Acrylic Phantoms

6.1 General

For dosimetry in high energy photon or electron beams all dosimetry protocols described in this document (IAEA TRS-398, AAPM TG-51, DIN 6800-2) require absorbed dose measurements in real water. Solid state phantoms may only be used for routine QA measurements, and a transfer factor has to be established [AAPM 51]. The phantom should extend at least 5 cm beyond all sides of the field and at least 5 cm beyond the maximum depth of measurement [IAEA 398].

This chapter helps to establish transfer factors and 'equivalent' measuring depths for measurements in acrylic (PMMA, Perspex, $C_5H_8C_2$) phantoms.

6.2 High energy photons

6.2.1 Conversion of measuring depth

Photon beams are attenuated and scattered differently in water and solid phantoms. To take these differences into account, correction procedures have to be carried out.

Differences in photon beams attenuation are determined by the ratio of the mean linear attenuation coefficients of water and PMMA. The measuring depth of water and PMMA. The measuring depth on water z_w can be determined from the measuring depth in PMMA z_p assuming the same source-detector-distance [AAPM 21].

$$z_w = 1.136 \cdot z_P \qquad \text{for } ^{60}\text{Co} \ldots 35 \text{ MV} \qquad (6\text{-}1)$$

6.2.2 Excess scatter correction

In PMMA phantoms the fraction of scattered photons is increased compared with water phantoms. To convert measuring values from PMMA to water, the measuring value has to be multiplied by a correction factor k_{ESC} (Excess Scatter Correction). Table 10 shows k_{ESC} values as a function of accelerator voltage and field size [AAPM 21].

6.3 High energy electrons

Solid phantoms may be used below 10 MeV to determine absorbed dose at z_{ref} [IAEA 398]. The measuring depth in water z_w can be determined from the measuring depth in PMMA z_p assuming the same source-detector-distance.

$$z_P = p \cdot c_{pl} \cdot z_P = 1.159 \cdot z_P \qquad (6\text{-}2)$$

c_{pl} is the depth scaling factor and p the nominal density of PMMA [IAEA 398/2]. The reading in the PMMA phantom M_p must be corrected by the fluence scaling factor h_{pl} to obtain the equivalent reading in water M

$$M = h_{pl} \cdot M_P = 1.009 \cdot M_P \qquad (6\text{-}3)$$

Energy (MV)	Depth (cm)	Field size at depth (cm²)			
		5x5	10x10	20x20	30x30
^{60}Co	0.5	0.997	0.996	0.995	0.996
	5.0	0.986	0.987	0.989	0.991
2	0.4	0.998	0.994	0.997	-
	5.0	0.984	0.982	0.989	-
4	1.0	0.998	0.997	0.998	-
	5.0	0.994	0.993	0.993	-
6	1.5	0.999	0.998	0.998	-
	5.0	0.994	0.994	0.996	-

Table 10: k_{ESC} as a function of energy and field size.

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Appendix A: Summary of PTW Chamber Data

PTW cylindrical chambers

Type No.	Chamber Name	Measuring Volume [cm^3]	Wall	Electrode	Wall Area Density [mg/cm^2]	Radius of Measuring Volume [mm]	Ion Collection Time at nominal HV
30001	Farmer	0.6	0.275 mm PMMA + 0.15 mm C	Al Ø 1mm	45[a]	3.05	0.14 ms (400 V)
30010	Farmer	0.6	0.335 mm PMMA + 0.09 mm C	Al Ø 1.1 mm	57[b]	3.05	0.14 ms (400 V)
30011 30002	Farmer, all graphite	0.6	0.425 mm C	C Ø 1 mm	79[b]	3.05	0.14 ms (400 V)
30012 30004	Farmer	0.6	0.425 mm C	Al Ø 1.1 mm	79[b]	3.05	0.14 ms (400 V)
30013 30006	Farmer, waterproof	0.6	0.335 mm PMMA + 0.09 mm C	Al Ø 1.1 mm	57[b]	3.05	0.14 ms (400 V)
31002	Semiflex	0.125	0.55 mm PMMA +0.15 mm C	Al Ø 1 mm Graphite coated	78[a]	2.75	0.10 ms (400 V)
31010	Semiflex	0.125	0.55 mm PMMA + 0.15 mm C	Al Ø 1.1 mm	78[a]	2.75	0.12 ms (400 V)
31021	Semiflex 3D	0.07	0.57 mm PMMA + 0.09 mm C	Al Ø 0.8 mm	84[b]	2.4	0.118 ms (400 V)
31003	Semiflex	0.3	0.55 mm PMMA + 0.15 mm C	Al Ø 1.5 mm Graphite coated	78[a]	2.75	0.08 ms (400 V)
31013	Semiflex	0.3	0.55 mm PMMA + 0.15 mm C	Al Ø 0.9 mm	78[a]	2.75	0.12 ms (400 V)
23331	Rigid Stem	1.0	0.40 mm PMMA + 0.15 mm C	Al Ø 1.5 mm Graphite coated	60[a]	3.95	0.21 ms (400 V)
30015	Rigid Stem	1.0	0.4 mm PMMA + 0.135 mm C	Al Ø 1.1 mm	73[b]	3.95	0.24 ms (400 V)
23332	Rigid Stem	0.3	0.35 mm PMMA + 0.15 mm C	Al Ø 2 mm Graphite coated	54[a]	2.5	0.04 ms (400 V)
30016	Rigid Stem	0.3	0.35 mm PMMA + 0.135 mm C	Al Ø 0.85 mm	67[b]	2.5	0.08 ms (400 V)
31014	PinPoint	0.015	0.57 mm PMMA + 0.09 mm C	Al Ø 0.3 mm	85[b]	1.0	0.02 ms (400 V)
31023	PinPoint	0.015	0.57 mm PMMA + 0.09 mm C	Al Ø 0.6 mm	85[b]	1.0	0.013 ms (300 V)
31015	PinPoint	0.03	0.57 mm PMMA + 0.09 mm C	Al Ø 0.3 mm	85[b]	1.45	0.04 ms (400 V)
31016	PinPoint 3D	0.016	0.57 mm PMMA + 0.09 mm C	Al Ø 0.3 mm	85[b]	1.45	0.06 ms (400 V)
31022	PinPoint 3D	0.016	0.57 mm PMMA + 0.09 mm C	Al Ø 0.6 mm	85[b]	1.45	0.045 ms (300 V)

[a] Graphite density 0.82 g/cm^3
[b] Graphite density 1.85 g/cm^3

PTW plane-parallel chambers

Type No.	Chamber Name	Measuring Volume [cm^3]	Entrance Window	Electrode Diameter [mm]	Window Area Density [mg/cm^2]	Electrode Distance [mm]	Ion Collection Time at nominal HV
34001	Roos	0.35	1.01 mm PMMA + 0.02 mm C + 0.1 mm Lacquer	15.6	132	2	0.13 ms (200 V)
34045	Advanced Markus	0.02	0.87 mm PMMA + 0.4 mm Air + 0.03 mm PE[c]	5	106[c]	1	0.02 ms (300 V)
23343	Markus	0.055	0.87 mm PMMA + 0.4 mm Air + 0.03 mm PE[c]	5.3	106[c]	2	0.09 ms (300 V)
23342	Soft X-Ray	0.02	0.03 mm PE	3	2.8	1	0.02 ms (300 V)
23344	Soft X-Ray	0.2	0.03 mm PE	13	2.8	1.5	0.04 ms (400 V)
34013	Soft X-Ray	0.005	0.03 mm PE	1.6	2.8	0.9	0.01 ms (400 V)

[c] with protection cap in place

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Some former detector types are not included in this catalog as they have been replaced by new types. The following table shows discontinued detector types and their replacements.

Replacements where dosimetric properties remain in good approximation identical

Detector name	Discontinued type	New type
Farmer, PMMA/Al	30001	30010
Farmer, graphite/Al	30004	30012
Farmer, waterproof	30006	30013
0.125 cm^3, semiflex	31002	31010
0.3 cm^3 semiflex	31003	31013
0.3 cm^3 rigid stem	23332	30016

Replacements where some dosimetric properties may change

Detector name	Discontinued type	Replaced by
PinPoint 0.015 cm^3	31014	31023
PinPoint 0.015 cm^3	31023	31022
PinPoint 3D 0.016 cm^3	31016	31022
Dosimetry Diode E	60017	60023
Dosimetry Diode P	60016	60022
Dosimetry Diode SRS	60018	60023

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For PTW, making medical radiation safer is both a passion and lifetime commitment. The family-run high-tech company operates the oldest and largest accredited calibration laboratory in the field of ionizing radiation and established THE DOSIMETRY SCHOOL to globally promote the exchange of knowledge in clinical dosimetry.

For more information on Detectors visit ptwdosimetry.com or contact your local PTW representative:
ptwdosimetry.com/en/contact-us/local-contact

PTW Freiburg GmbH
Lörracher Str. 7
79115 Freiburg · Germany
Phone +49 761 49055-0
info@ptwdosimetry.com
ptwdosimetry.com

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